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Extraction, Processing, Canning, and Keeping Quality of Acerola Juice

F. Sánchez Nieva[1]

INTRODUCTION

West Indian cherries (*Malpighia punicifolia* L), best known in Puerto Rico as "acerola," were shown by Asenjo, and Freire de Guzmán (1)[2] to contain from 1 to 3 gm. of ascorbic acid per 100 gm. of edible matter. This finding was confirmed by Mustard (4) who found the green fruit to contain about 4 gm. of the vitamin per 100 gm. of edible matter.

The high ascorbic acid content of the acerola suggested the possibility of using the juice as a source of the vitamin to enrich other juices and nectars (2). The possibility of using the acerola juice as such induced the author to study the canning and keeping quality of the juice. The present study deals chiefly with procedures for canning the juice and with the keeping quality of the product.

EXPERIMENTAL PROCEDURE

Ripe fruit from the trees grown at the Experiment Station Farm in Río Piedras were used. The fruit was picked when fully mature but still firm, and brought immediately to the laboratory. Whenever feasible, the fruit was processed immediately. When immediate processing was not feasible, the fruit was stored at 45°F. for no more than 3 days. During the peak of the season, when more fruit than could be processed in a reasonably short time was delivered to the laboratory, the excess was frozen solid and stored at 10°F. Frozen fruit was thawed overnight before processing.

The juice was extracted by pressing the whole fruit in a homemade cider press through white duck bags. When the fruit was too firm to give a high

[1] Chemist, Head of Chemistry Department, Agricultural Experiment Station, University of Puerto Rico, Río Piedras, P. R. The author wishes to express his thanks to C. Moscoso and F. Aróstegui for supplying the fruit used in this work. Appreciation is expressed to R. Santini, Jr., who provided the data on the behavior of the sugars during storage. B. López Ramos, A. J. Rodríguez, J. Escabí, and E. Sotelo cooperated in the laboratory work.

[2] Numbers in parentheses refer to Literature Cited, p. 183.

yield of the juice, it was broken into a mash by means of a high-speed stirrer before processing.

The extracted juice was centrifuged in a solid-basket centrifugal to remove the pulp in suspension. When the solids in suspension could not be completely removed by centrifugation, the juices were filtered in a frame-and-plate filter press using Hyflo Supercell.

The juices were flash-pasteurized in a tubular heat exchanger at 190°F. for 45 seconds, canned in No. 2 plain tin (1.25) or sanitary enameled containers, followed by 1-minute holding of the inverted cans and rapid cooling.

The canned juices were stored at 45°F. and at room temperature of 80°–85°F. for 1 year. Samples were regularly assayed for ascorbic acid, pH, total acidity, and reducing sugars. The ascorbic acid was determined by the iodometric titration of Ballantine (3). Total acidity was determined by electrometric titration with sodium hydroxide, using a glass and calomel electrode system. Reducing sugars were determined by the method of Santini (5).

RESULTS

YIELDS OF JUICE

The yields of juice obtained from several lots of fruits processed are given in table 1. As is seen from these figures, the average yield of juice when the fruit was pressed in the homemade hydraulic press varied from about 59 to 73 percent. This variation in the yield of juice can be attributed to the rather poor performance of the press. The pressure was applied by means of a 5-ton hydraulic jack and it was almost impossible to obtain uniform pressure in all the experiments. Variations in yields can also be attributed to the ripeness of the fruit being processed, mature fruit giving higher yields than greener fruit.

TABLE 1.—*Yields and ascorbic acid content of acerola juice*

Weight of fruit (pounds)	Weight of juice extracted	Juice in fruit	Ascorbic acid in juice
	Pounds	*Percent*	*Gm. per 100 ml.*
222.0	134.5	60.58	1.29
235.0	139.0	59.02	1.22
279.0	182.0	65.20	1.18
195.5	130.0	66.49	1.20
108.0	58.5	54.00	1.21
67.0	40.4	60.36	1.50
326.0	105.0	62.88	1.37
195.0	132.0	67.69	1.69
214.5	157.5	73.42	1.32

Although, as reported by Mustard (4), and later verified in this laboratory, the green fruit contains more ascorbic acid than the ripe, the processing of ripe fruit offers the advantage of higher yields of juice, and consequently, higher recovery of ascorbic acid. If the green fruit is to be processed, it is necessary to mash it in water in order to obtain a mash fluid enough for pressing. Pressing of green fruit without mashing in water could not be carried out with the equipment at our disposal.

The extraction of the juice by pressing the fruit in a screw press was attempted. A pulpy juice was obtained which could not be clarified easily. As will be shown later, the presence of pulp in the juice was found to be detrimental and, therefore, pressing in the screw press was abandoned.

The juice obtained from the hydraulic press was cherry red in color and fairly transparent. The ascorbic acid content varied from 1.18 to 1.69 gm. per 100 ml., as indicated in table 1. The recovery of ascorbic acid in the process in terms of the ascorbic acid present in the fruit was found to have an approximate average value of 75 percent.

EFFECTS OF PROCESSING

When the juice containing pulp in suspension was heated, the pulp coagulated and a yellowish precipitate appeared. When the juice was clarified, the formation of this precipitate could be prevented. The juice from the press which contained a fairly small quantity of pulp in suspension, was centrifuged in a solid-basket centrifugal 12 inches in diameter at 2,100 r.p.m. The centrifuge was generally fed 2 to 3 gallons of juice per minute, and the juice was permitted to overflow the basket. Centrifugation removed a yellow solid in suspension, yielding a more reddish-colored juice. The loss of ascorbic acid during centrifugation was found to be negligible. In the several batches of juice centrifuged, the loss of ascorbic acid never amounted to more than 1 to 2 mg. per 100 ml., as can be seen in table 2.

The appearance of the juice was greatly improved by filtration. Filtra-

TABLE 2.—*Change in ascorbic acid content of juice of the acerola during centrifugation and pasteurization, in grams per 100 ml. of juice*

Exracted juice	Centrifuged juice	Pasteurized juice
1.29	1.29	1.28
1.22	1.25	1.22
1.18	—	1.17
—	1.34	1.14
—	1.169	1.14
1.69	1.691	1.63
1.32	1.31	1.23

tion of the juice at room temperature was successfully carried out in a frame-and-plate filter press using 0.2 percent of Hyflo Supercell. Paper of medium porosity previously precoated with the filter-aid assured a uniform flow of juice from the filter press. The loss of ascorbic acid during filtration was found to be about 73 mg. per 100 ml. of juice.

When the clarified juices were flash-pasteurized at 190°F., the loss of ascorbic acid was fairly small, as is shown in table 2.

When the juice was heated for about 45 seconds at 190°F., the color changed from cherry red to orange red or yellow. When heated for a longer period, the change in color was more pronounced.

Canning of the juice under vacuum, followed by pasteurization in the can at 190°F., resulted in a slighter change in color. The change in color that takes place when the juice is heated can be attributed to the decomposition of the pigment, probably anthocyanin,[3] which exhibits a similar behavior when heated in the presence of ascorbic acid (6).

The type of container used to can the juice has a direct effect on the color and appearance of the product. When plain tin cans (1.25-lb. tin B/B) were used, rapid deterioration of the color took place with the formation of a yellow precipitate. The use of sanitary F-enamel containers improved the appearance of the product. The juice canned in this type of container changed in color from the deep cherry red to a reddish orange. If the juice was filtered free of suspended or colloidal solids, no precipitate formed and the juice remained clear through the storage period. Similar results were obtained with glass containers and with enameled cans with side-seam striped.

EFFECTS OF STORAGE AT DIFFERENT TEMPERATURES

In the course of this work it was observed that the cans of the juice stored at room temperature (85°F.) usually showed swelling in less than a month. Bacterial counts[4] made from these samples showed that the product was generally sterile and free from gas-forming bacteria. In no case could swelling be attributed to fermentation. Neither could swelling be attributed to hydrogen production. Swelling took place in both plain tin and enameled containers. Qualitative tests showed that most of the gas produced was carbon dioxide.

In table 3 are tabulated the results of the determinations of ascorbic acid and reducing sugars in samples of canned acerola juice stored at room temperature. Changes in acidity and pH are shown for the same storage tem-

[3] Work in progress in this laboratory indicates that the pigment present in the acerola juice has characteristics similar to those of anthocyanin.

[4] Counts made by R. Córdova of the Faculty of Natural Sciences of the University of Puerto Rico.

TABLE 3.—*Keeping quality of pasteurized West Indian cherry juice stored at room temperatures of 80° to 85° F.*

Storage age (months)	Ascorbic acid content	Reducing-sugar content	Loss of ascorbic acid
	Sample 1		
	Gm./100 ml.	*Percent*	*Percent*
0	1.12	3.6	
1	1.06	3.6	
2	1.06	3.6	
3	.98	3.7	
6	.74	3.7	
12	.52	3.7	53.5
	Sample 2		
0	0.91	3.0	
1	.87	3.0	
2	.79	3.0	
3	.77	3.0	
6	.61	3.1	
12	.37	3.1	81.5
	Sample 3		
0	1.03	3.4	
1	.97	3.4	
2	.87	3.4	
3	.85	3.5	
6	.67	3.7	
12	.41	3.4	60.2
	Sample 4		
0	1.14	3.5	
1	1.03	3.5	
2	.93	3.5	
3	.91	3.4	
6	.86	3.6	
12	.45	3.5	60.5
	Sample 5		
0	0.84	3.4	
1	.84	3.3	
2	.8	3.4	
3	.74	3.4	
6	.62	3.3	
12	.37	3.4	56.0

TABLE 4.—*Changes in total acidity, pH, and ascorbic acid of pasteurized West Indian cherry juice stored at room temperature of 85°F.*

Storage age (months)	Total acidity	Ascorbic acid	pH
	Sample 1		
	Percent	*Gm./100 ml.*	
0	0.84	1.28	3.6
1	.83	1.16	3.5
2	.81	1.16	3.4
3	.81	.99	3.5
5	.80	.98	3.6
7	.80	.93	3.5
9			
	Sample 2		
0	0.85	1.22	3.7
1	.85	1.11	3.5
2	.84	1.11	3.4
3	.82	.95	3.6
5	.81	.93	3.5
7	.80	.86	3.5
9	.80	.72	3.7
	Sample 3		
0	0.88	1.14	3.5
1	.89	1.06	3.4
2	.88	1.06	3.4
3	.81	.93	3.5
5	.85	.91	3.5
7	.84	.83	3.4
9	.82	.71	3.6

perature in table 4. Similar data appear in table 5 for samples stored at 45°F.

When the juice was stored at room temperature the loss of ascorbic acid ranged from 53.5 to 81.5 percent of the amount originally present. No change was observed in the reducing-sugar content. When stored at 45°F. the loss in ascorbic acid ranged from 10.8 to 21.2 percent of the amount originally present. Again no change was observed in reducing sugar.

Since the change in color during storage is accelerated by a high temperature, the acerola juice should be stored at 45°F., or lower, to prevent this and to insure maximum retention of the ascorbic acid. When frozen without pasteurization less change takes place and the ascorbic acid is fairly well

TABLE 5.—*Changes in reducing-sugar and ascorbic acid content of pasteurized West Indian cherry juice stored at 45°F.*

Storage age (months)	Ascorbic acid content	Reducing-sugar content	Loss of ascorbic acid
	Sample 1		
	Gm./100 ml.	*Percent*	*Percent*
0	1.12	3.6	
1	1.12	3.5	
2	1.18	3.6	
3	1.18	3.6	
6	1.02	3.7	
12	1.01	3.5	10.8
	Sample 2		
0	0.91	3.0	
1	.96	2.9	
2	.90	3.1	
3	.90	3.0	
6	.81	3.1	
12	.72	3.2	20.8
	Sample 3		
0	1.03	3.4	
1	1.08	3.4	
2	.992	3.4	
3	.985	3.4	
6	.915	3.5	
12	.823	3.5	20.5
	Sample 4		
0	1.14	3.5	
1	1.15	3.4	
2	1.06	3.4	
3	1.06	3.5	
6	1.02	3.7	
12	.901	3.6	21.2
	Sample 5		
0	0.84	3.4	
1	.95	3.3	
2	.90	3.3	
3	.87	3.3	
6	.82	3.4	
12	.78	3.5	7.2

TABLE 6.—*Changes in ascorbic acid content of stored frozen West Indian cherry juice*

Sample No.	Ascorbic acid content of frozen West Indian cherry juice aged—			
	2 months	4 months	10 months	12 months
	Mg./100 ml.	*Mg./100 ml.*	*Mg./100 ml.*	*Mg./100 ml.*
I	0.73	0.67	0.67	0.67
II	.65	.62	.62	.60

retained, as shown in table 6. Freezing also prevents changes in color and flavor.

FLAVOR

Heating and canning altered the flavor of the acerola juice. The pleasant flavor of the freshly extracted juice changed during heating with the development of a haylike flavor. This change in flavor, however, did not prevent the use of the juice as a source of ascorbic acid. It was shown in the course of this work that the addition of the acerola juice to products like pear and apricot nectar, and to grape juice, did not cause any appreciable change in flavor, when made at a rate of 1 part of the acerola juice to 27 parts of the product. This rate is high enough to increase the ascorbic acid content to about 50 to 60 mg. per 100 ml.

SUMMARY

The juice is best extracted from the acerola by pressing the mashed fruit in a cider press. The recovery of juice varies from about 59 to 73 percent of the weight of the fresh fruit used, depending on the pressure applied and the ripeness of the fruit. The extracted juice is clarified by centrifugation followed by filtration using Hyflo Supercell. Although pasteurization of the juice causes but a slight loss of the ascorbic acid content, it induces a change in color and flavor of the juice. The product must be canned in enameled cans to prevent excessive discoloration.

When the juice was stored at room temperature (80° to 85°F.) the loss of ascorbic acid during 1 year amounted to from 53.5 to 81.5 percent. The loss of ascorbic acid is minimized by storage at 45°F. Juices stored at 45°F. suffered a maximum loss of ascorbic acid of about 20 percent during 1 year.

Although the flavor of the juice changed during processing, the product can be used as a source of ascorbic acid to enrich other products without detrimentally affecting their taste. Only 1 part of the juice need be added to 27 parts of the product to be enriched with no appreciable change in flavor of the enriched product.

RESUMEN

El jugo de la acerola se extrae exprimiendo la fruta, previamente triturada, en una prensa hidráulica. La recuperación del jugo varía entre un 59 y un 73 por ciento. El rendimiento depende de la presión que se le aplique a la prensa y del estado de madurez de la fruta. El jugo extraído se clarifica por centrifugación y luego se filtra usando un agente filtrador como Hyflo Supercell. Cuando el jugo se pasteuriza, hay una pérdida pequeña en su contenido de ácido ascórbico. Al pasteurizar el jugo, este sufre un cambio en su color y sabor. El jugo debe ser enlatado en latas esmaltadas para evitar un cambio excesivo en el color.

Cuando el jugo de la acerola se almacena a una temperatura de 85°F., la pérdida de ácido ascórbico varía entre 66 y 80 por ciento del contenido original, al cabo de un año. Cuando los jugos se almacenan a 45°F., por un año, la pérdida de ácido ascórbico asciende a solament un 20 por ciento. Aún cuando el sabor del jugo cambia durante el proceso de enlatado, éste puede usarse como fuente de ácido ascórbico para enriquecer otros productos. La adición de 1 parte del jugo de acerolas a 27 partes del jugo a ser enriquecido, es suficiente para enriquecer el producto sin causar cambios en el sabor del mismo.

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Extraction of Ascorbic Acid from Acerolas (*Malpighia punicifolia* L.)

R. Santini, Jr., and J. Nevarez[1]

INTRODUCTION

Asenjo and Freire de Guzmán (1)[2] have shown that the acerola is the best natural source of ascorbic acid. The content of ascorbic acid in the fruit ranges from 1.03 to 2.70 gm. per 100 gm. of edible pulp. The results obtained by Asenjo were confirmed by Vieta de Ruiz, *et al.*, (2) in Cuba, and by Mustard (3) in Florida. Working along the same line, values which correspond with those reported by Asenjo have been obtained in the Chemistry Department of the Agricultural Experiment Station of the University of Puerto Rico.

Experiments carried out at this Station have shown that the ascorbic acid content of the acerola juice suffers little change when the juice is flash-pasteurized and canned (4). During storage for 1 year at 45°F., about 82 percent of the ascorbic acid content of the juice is retained, but when stored at room temperature only about 50 percent is retained (5).

The high ascorbic acid content of the acerola juice makes its use desirable as a dietary supplement in ascorbic acid deficiencies. However, the use of the acerola juice is at present limited by the darkening of the juice and the concurrent loss of flavor that takes place on pasteurization and canning.

LITERATURE REVIEW AND OBJECTIVES

Various methods have been used for the isolation of ascorbic acid from plant extracts. These have generally involved organic-solvent fractionation, heavy-metal-salt precipitation, or both. Attempts to apply these procedures in the laboratory indicated that the methods were too indirect and inefficient to have commercial possibilities in competition with synthetic ascorbic acid.

Asenjo, *et al.*, used the lead-salt precipitation method of Banga and Szent-Györgyi (6) to confirm the presence of ascorbic acid in the acerola. The method is very efficient, but requires the use of lead salts, which, besides being very expensive, are very poisonous. A more recent method suggested is the chromatographic method of Sastri and Sivaramakrishan (7) which

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[2] Numbers in parentheses refer to Literature Cited, p. 189.

uses activated magnesia as the absorbent. Some preliminary work was done using this method for the acerola, but the results were very poor.

A third method found in the literature is that of Mottern and Buck (8). They developed a process for the recovery of ascorbic acid from citrus and other natural products by the use of ion-exchange resins. This method was subsequently patented in 1944, and is under license to the Permutit Co. However, we were unable to obtain the ascorbic acid in crystalline form by using this method.

Mottern and Buck recommend a 10-percent sulfuric acid solution to elute the ascorbic acid from the column. When we tried to eliminate the sulfuric acid in excess by precipitation with barium chloride and then concentrate the filtrate to 10 percent of its original volume, almost all the ascorbic acid was lost. In a letter that we received from A. B. Mindler, Special Applications Department of the Permutit Co., regarding the crystallization of the ascorbic acid, the following information was given:

> It is true that U. S. Patent 2,443,583 is under license to the Permutit Co. but I do not know whether we can aid you very much in your work of developing a process employing ion-exchange for ascorbic acid recovery since the problem of ascorbic acid crystallization has not been solved for the recovery of ascorbic acid from the elution solutions.

Klose, *et al.*, (9) at the Western Utilization Research Branch, USDA, developed a more direct method for the isolation of ascorbic acid from green walnut hulls. Their experimental procedure may be summarized as follows: Extraction of the vitamin from the hulls using a dilute SO_2 solution, purification of the extracts by absorption on, and the elution from anion-exchange resins; and crystallization from the concentrated, decolorized eluate.

This method worked very well, but it could not be applied commercially because there is only one crop of the walnuts during the year and because the process of extraction of the ascorbic acid from the hulls with dilute SO_2 solution is very expensive. However, since the acerola yields from two to four crops during the year, since these fruits have a higher ascorbic acid content than the green walnut hulls and further, since the ascorbic acid in the acerolas is found dissolved in the juice, making the cost of the extraction of the ascorbic acid from the fruit very small as compared to the procedure required for extracting the acid from the green walnut hulls, it seemed as if ion-exchange might be used commercially to isolate the ascorbic acid from the juice of pressed acerolas.

EXPERIMENTAL PROCEDURE

The procedure developed by the authors for recovering the ascorbic acid from acerola juice is as follows: The juice is passed through a cation-

exchanger in the acid cycle until the pH drops to less than 2. Then it is passed through an anion-exchange resin in the alkaline cycle (this was preferred to the method used at the Western Utilization Research Branch of putting an anion-exchanger into the acid cycle). The anion-exchange columns are washed with distilled water and the elution is carried out using a dilute solution of HCl. The eluate is then decolorized, using Norit A, and is concentrated to 65°Brix. The concentrate is left at 0°C. for 2 days and the crystals are then washed with N-butyl alcohol and dried.

The cation-exchanger used so far has been Amberlite IR-120 and the anion-exchanger has been Amberlite IR-4B. These have proved to be very efficient. However, more research remains to be done with different resins to find the anion-exchanger which has the greatest capacity for the ascorbic acid.

A 0.5N HCl solution was used for the elution. Other concentrations of HCl were tried, and this seemed to be satisfactory. Additional work in this connection should yield information as to the most suitable and economic concentration.

RESULTS

In the elution procedure an average of about 77 percent of the adsorbed ascorbic acid can be recovered from the column. Table 1 shows the recovery obtained in several experiments conducted.

Although the percentage recovery of the ascorbic acid from the anion-exchange column is very high, more research will be required to obtain higher yields. This work will include such factors as the time the acid is in contact with the resin, the volume required for as complete an elution as possible, the size of the columns, and the substitution of other acids for HCl.

TABLE 1.—*Recovery of ascorbic acid from the anion-exchanger by elution with 0.5N HCl*

Sample No.	Ascorbic acid adsorbed	Ascorbic acid eluted	Recovery of ascorbic acid
	Grams	*Grams*	*Percent*
1	63.8	50.8	79.6
2	62.0	44.2	71.3
3	133.0	95.0	71.4
4	180.0	140.0	77.8
5	180.0	108.0	60.0
6	191.0	147.2	77.0
7	161.0	137.9	85.7
8	198.6	190.3	96.0
Average			77.4

TABLE 2.—*Concentration of ascorbic acid, by volume, during the elution procedure in 7 experiments*

Eluate No.	Normality of acid	Volume of acid used	Amount of ascorbic acid in eluate—						
			1	2	3	4	5	6	7
			Experiment 1						
		Milliliters	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*
1	0.1	500	0.11	0.11	0.07	0.29	0.02		
2	.1	500	1.39	2.19	.95	1.03	.87		
3	.1	500	1.18	1.16	.78	.89	1.54		
4	.1	500	1.69	.62	1.77	.87	.88		
5	.1	500	1.09	1.34	.45	.70	.47		
6	.1	500	.49	.85	.33	.71	.45		
7	.1	500	.31	.33	.45	.56	.20		
			Experiment 2						
1	0.2	500	4.49	0	0	0	0		
2	.2	500	6.76	5.92	6.56	2.98	3.85		
3	.2	500	5.23	2.71	2.94	1.22	2.51		
4	.2	500	.75	.95	.50	.64	.70		
			Experiment 3						
1	0.5	500	3.41	3.23	0.28	0.28	0.38	8 43	
2	.5	500	6.72	5.18	2.71	2.75	3.32	3.25	
3	.5	500	5.46	7.36	9.52	9.39	7.59	8.09	
4	.5	500	1.53	1.12	2.03	2.63	1.58	1.73	
5	.5	500	0	0	0	0	0	1.85	
			Experiment 4						
1	0.5	500	0	0	1.87	1.98	1.08	0	
2	.5	1,000	9.66	10.09	5.82	9.31	9.57	8.22	
3	.5	1,000	8.09	7.00	2.08	4.70	7.57	10.04	
4	.5	500	1.96	0	0	.10	.35	4.70	
			Experiment 5						
1	0.5	1,000	4.98	5.58	4.76	6.43	5.84	3.58	
2	.5	1,000	11.89	10.37	10.35	5.47	9.97	11.03	
3	.5	500	3.30	1.85	1.60	.44	1.74	4.22	
			Experiment 6						
1	0.5	1,000	4.65	12.54	5.46	2.90	6.82	6.42	8.95
2	.5	1,000	13.37	9.77	11.61	15.4	9.32	9.24	9.78
3	.5	1,000	2.64	1.32	2.16	3.0	1.05	.97	4.27
			Experiment 7						
1	0.5	500	1.45	1.85	.79	1.14	1.23	1.19	0.88
2	.5	1,000	11.88	10.12	11.78	11.66	11.70	10.25	10.82
3	.5	1,000	3.70	3.10	2.37	5.2	5.35	4.00	3.96

The concentration of ascorbic acid by volume in the elution is summarized in table 2, which shows that the ascorbic acid content rises to a maximum in the second or third elution and then drops.

Klose, *et al.*, recommended that the eluate be concentrated *in vacuo* to about 40-percent solids, decolorized, and then further concentrated to 70-percent solids. We have found that it is better to decolorize the eluate before concentrating *in vacuo*, because with a dilute solution the loss of ascorbic acid during decoloration is reduced to a minimum, and the loss which occurs in the handling of the sample (taking the sample out of the evaporator, decolorizing, and returning it to the evaporator) is eliminated.

Crystallization occurred after standing at 0°C. for 2 days. The crystals were washed with N-butyl alcohol and dried, but when this alcohol had not purified the ascorbic acid completely, a recrystallization was made from ethyl alcohol. The vitamin was identified by determination of its melting point (190–192°C.), by mixed melting-point determination with synthetic ascorbic acid, by titration with 1,2 dichlorophenol indophenol (10), and by determination of its specific rotation (+21.3°).

In one of our experiments a decolorized eluate containing 146 gm. of ascorbic acid was concentrated to 65°Brix and allowed to crystallize at 0°C. for 2 days. The crystals were washed with N-butyl alcohol and then recrystallized from ethanol and 85 gm. of pure ascorbic acid were obtained. Since about 20 gm. remained in the low-temperature evaporator and 30 gm. remained in the mother liquor, the yield for a continuous process would be 88 percent.

This process could be worked continuously with very high yields because: 1, The resins could be regenerated and used for a very long time; 2, the percentage of recovery of ascorbic acid from the column was very high; 3, the amount lost during decolorization was negligible; 4, the amount lost in the concentration operation was only that left as a film on the walls of the evaporator and, in a continuous process this would be negligible; 5, the amount of ascorbic acid which stayed in the mother solution after crystallization could be added to fresh juice which had been passed through the cation-exchangers and again subjected to the process, hence the amount remaining in the mother solution was always constant and, in a continuous process, it would be negligible as well.

SUMMARY

The acerola is considered to be the best natural source of ascorbic acid, it yields from two to four crops during the year, and the ascorbic acid is found dissolved in the juice.

Therefore, a method which was used previously for separating and crystallizing the ascorbic acid present in the green walnut hulls, but which

could not be applied commercially thereto, has been modified and applied to the acerola.

The method involved the use of ion-exchange resins. A cation-exchange resin was used to lower the pH below 2 and an anion-exchange resin to absorb the ascorbic acid. This acid was eluted from an anion-exchange column with a dilute hydrochloric acid solution.

On a laboratory scale the yields obtained were relatively high and in a continuous commercial process the yield should be about 88 percent.

RESUMEN

La acerola se considera como la mejor fuente de ácido ascórbico. Se obtienen de dos a cuatro cosechos de esta fruta durante el año y el ácido ascórbico se encuentra disuelto en el jugo.

Un método que se usó originalmente para extraer y cristalizar el ácido ascórbico de la cáscara de las nueces verdes, pero que no se pudo usar comercialmente, ha sido modificado y aplicado a la acerola.

El método conlleva el uso de resinas que intercambian iones. Una resina que intercambia cationes se usa para bajar el pH del jugo de acerola a 2 y una resina que intercambia aniones se usa para absorber el ácido ascórbico. Este se extrae de la resina con una solución diluída de ácido clorhídrico.

El rendimiento obtenido en escala de laboratorio fué alto y se espera que en un proceso comercial el rendimiento sea alrededor de 88 por ciento.

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A Chlorotic Streak Disease of Merker Grass (*Pennisetum purpureum*)

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INTRODUCTION

In the summer of 1952, near Coloso, P.R., chlorotic streaks, sometimes discontinuous, and with wavy margins, were observed running for various lengths on large, expanded leaves of *Pennisetum purpureum* Schumac. Microscopic examinations gave no evidence of an associated pathogen. The similarity of these streaks to those of chlorotic streak disease of sugarcane, and the occurrence of heavily diseased sugarcane in an adjoining field, suggested that they might have the same causal agent.

Cuttings of selected diseased stems of *P. purpureum* were subjected to the hot-water treatment effective in rendering sugarcane free from the chlorotic streak virus of that host (7),[2] and the grass was rendered disease-free. The hypothesis that these diseases might be the same was supported by the fact that the chlorotic streak-diseased grass was found growing in association with chlorotic streak-diseased sugarcane, it occurred most abundantly in humid areas known to favor this disease in sugarcane, the same hot-water treatment was effective in control, and the leaf-blade symptoms were similar (4, 5). As no hosts of chlorotic streak of sugarcane other than *Saccharum* spp. were known, other grasses were examined for the possible presence of this disease.

Similar symptoms were found in several strains of *Pennisetum purpureum*, in hybrids of *P. glaucum* and *P. purpureum*, in *Panicum maximum* L., and in *Erianthus* spp. (5). The *Erianthus* grasses are closely related to sugarcane and are fertile in crosses with cane, but the other two genera are further removed, particularly *P. maximum*. *Erianthus arundinaceus* was grown in a sugarcane-breeding nursery and symptoms were more evident on it than on the sugarcanes. The chlorotic streaks were observed on *P. maximum* only at Río Piedras in a low, wet clay-soil area, and as this grass is generally grown in the more arid regions it may not suffer economic losses.

Strains of *P. purpureum*, particularly Merker grass, are widely cultivated

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[2] Numbers in parentheses refer to Literature Cited, p. 196–7.

in the humid parts of the Island, and are a mainstay in the livestock enterprises. Knowledge as to the host range of the virus would aid in sugarcane-breeding work. It would be important to know whether these and other grasses are hosts of the sugarcane chlorotic streak virus and aid in increasing the populations of insect vectors, and in these roles constitute a hazard to the sugarcane crop and industry. In Louisiana the chlorotic streak-disease virus is transmitted by the leaf hopper, *Draeculacephala portola* (3), but no transmission studies were conducted to determine definitely the relationships among these apparently similar diseases in Puerto Rico.

Merker grass, a commercial strain of *P. purpureum* widely grown in humid areas, is of major importance in its own right, regardless of any possible role as an additional host of a major disease of sugarcane. It is vegetatively propagated and withstands the hot-water treatment well.

METHODS AND RESULTS

The observations reported herein indicate the value of using disease-free Merker grass seed, that there are differences in susceptibility among strains of *P. purpureum*, and that the chlorotic streak disease of that grass is capable of causing heavy losses in forage production.

EXPERIMENT 1

Several strains and hybrids of *Pennisetum* spp. were grown along with other grasses in a comparative-yield experiment in the low wet lands of the Experiment Station at Río Piedras. This trial was adjacent to sugarcane suffering from chlorotic-streak disease. The seed[3] of this trial came from two sources: Increase blocks adjacent to diseased cane, and a grass nursery somewhat isolated from sugarcane. These grasses were observed for the presence of chlorotic streak symptoms to detect any differences in degree of infection present among grass strains, and the influence of seed source on the extent of the disease present (table 1).

The incidence of the disease present was influenced by both seed source and strain of the grass. Those grasses grown from seed sources adjacent to diseased cane were infected to a greater degree than those from the grass nursery. The fourth grass listed in table 1 had become far more diseased than any other present in the trial. This disease should be considered in the development of strains of *P. purpureum* for the humid areas, but of more importance would be a program to eliminate the disease through the use of clean seed.

[3] In the case of *P. purpureum* "seed" refers to vegetative stem cuttings, usually of three nodes, the same as in sugarcane.

TABLE 1.—*Chlorotic streak disease observed in a grass trial at Río Piedras*

Grass	Number of plants diseased, Aug. 2, 1953	Disease rating[1] July 30, 1954
1. Merker, *Pennisetum purpureum*	—	34[2]
2. Elephant, *P. purpureum*	—	19
3. Merkeron, *P. purpureum*	10	31[2]
4. 29722 × short (16 × 18 (3:1)), *P. purpureum*	218	544[2]
5. 29722 × short (16 × 18), *P. purpureum*	11	15[2]
6. 29722 × millet 16 (1:1), *P. purpureum* × *P. glaucum*	40	61[2]
7. Selection 169, *P. purpureum*	—	2
8. Guinea (local), *Panicum maximum*	—	0
9. Guinea (from Brazil), *P. maximum*	—	4
10. Hybrid 73-50, *P. purpureum*	—	0
11. Hybrid 73-51, *P. purpureum*	—	0
12. Hybrid 73-52, *P. purpureum*	—	0
13. Hybrid 73-53, *P. purpureum*	—	0
14. Hybrid 73-54, *P. purpureum*	—	3

[1] Plants showing leaf symptoms but little or no stunting were rated 1, moderate stunting 2, severe stunting 3, and dead plants 4.

[2] Seed from the increase block. Seed for the others came from a nursery in which chlorotic streak was rare.

EXPERIMENT 2

An experiment designed to determine the practicability of the hot-water treatment to prevent chlorotic streak disease on a commercial improved strain of *P. purpureum* (Merker grass) and to provide an estimate of the effect of the disease on yield and quality of forage was conducted at Lajas, P.R., on a black, alkaline, somewhat salty soil where irrigation water was available. The diseased seed was obtained from individually selected stalks with one or more leaves showing clear symptoms of chlorotic streak near Central Coloso[4] in western Puerto Rico.

Apparently healthy seed was selected at Río Piedras from a field known to be relatively free from this disease. The leaves were removed and the stems cut into 3-node segments. The diseased and apparently healthy seed lots were divided equally. One-half of each lot was treated in hot water (52°C.) for 20 minutes. It was planted October 8, 1953, in six replicates in plots of four 16-foot rows, 2 feet apart. Each plot of apparently healthy and apparently healthy-treated seed received 30 seed pieces (14.5 pounds), and each diseased and diseased-treated plot 45 seed pieces (11 pounds). A greater number of diseased than of disease-free seed pieces was used in an

[4] The authors wish to express their appreciation for the cooperation of the management of Central Coloso, and particularly to Nicolás Cardona and Hector Martínez.

A

B

FIG. 1.—A, Merker grass in a diseased-treated plot (left) adjacent to a diseased plot (right) is taller, darker green, and the leaves are more turgid. B, The left-hand bundle is from an apparently healthy-treated plot, the right-hand bundle from a diseased plot.

TABLE 2.—*Production of forage by Merker grass* (Pennisetum purpureum *var.* Merkerii) *from diseased, diseased hot-water-treated, apparently healthy, and apparently healthy hot-water-treated lots of seed at Lajas, October 8, 1954—January 14, 1955*[1]

Seed lot[2]	Yield in pounds for each of 5 cuttings					Total
	1	2	3	4	5	
Diseased	103.09	91.11	161.72	296.93	84.76	146.64
Diseased-treated	125.78	136.49	323.25	403.30	134.23	224.49
Apparently healthy	134.67	128.87	366.08	465.73	130.50	245.18
Apparently healthy-treated	138.30	175.70	351.93	502.03	136.30	260.86
Cutting means	125.45	123.03	300.74	417.00	121.29	

[1] The data are imperfect in that by Mar. 10, 1954, 59 apparently healthy plants were growing in the diseased plots, and there were a few diseased plants in the healthy plots: 4 in the diseased-treated; 4 in the apparently healthy-treated; and 11 in the apparently healthy.

[2] Least significant difference between: 2 treatment means at 5 percent, 14.72, at 1 percent, 19.49; 2 cutting means at 5 percent, 16.47, at 1 percent, 21.78; 2 means of different treatments within same cutting at 5 percent, 32.89, at 1 percent, 43.58.

effort to compensate for its weakness and obtain approximately equal stands. A minimum of irrigation water was used, and a light application of nitrogenous fertilizer was added following the second harvest. The plots (fig. 1) were maintained weed-free. The grass was cut on five dates near the ground line, green weights were obtained, and analyses for nitrogen content made.

Germination was adequate in all plots. Differences in rate of growth were apparent from the first, but diseased plants became increasingly weaker with time. The production in the diseased plots was 65.3, 59.8, and 56.2 percent (table 2) of that in the apparently healthy-treated plots in five harvests obtained from the experiment. These observations indicate that Merker grass suffers more severely from this disease than the sugarcane grown commercially in Puerto Rico.

In dry weather, the plants are severely stunted, the leaves are dull-green, curled, and wilted, a purple color is often marked in the leaf sheaths, and some mortality occurs. Although the disease usually develops and spreads naturally in humid areas, severe losses also occur during dry weather or when diseased seed of Merker grass is planted in arid regions. When water is abundant the grass appears to be more tolerant to the disease.

The disease delayed flower emergence of *P. purpureum* (fig. 2), and the total nitrogen[5] content of diseased plants exceeded that of healthy plants.

[5] Analyses made under the supervision of A. Riera, Agricultural Experiment Station, Río Piedras, P. R.

FIG. 2.—Flowering of Merker grass (*Pennisetum purpureum*) was delayed by chlorotic streak disease: Left-hand plant moderate to severely diseased, center plant lightly diseased, right-hand apparently healthy.

Delayed flowering and increased protein content (9.15 percent of protein in diseased, 7.76 percent of protein in healthy) both indicate an interference with normal maturation.

DISCUSSION AND SUMMARY

The chlorotic streak disease of Merker grass (*Pennisetum purpureum* Schumac.) has many features in common with the chlorotic streak disease

of sugarcane. The leaf symptoms are similar. Both are carried in seed pieces, and seed of both is rendered disease-free by submerging in hot water (52°C.) for 20 minutes. The diseased grass usually grew close to diseased sugarcane, or on a site adjacent to diseased cane. Infection in both cane (1, 6) and the grass results in heavy losses in tonnage. Some experiments with sugarcane (1, 6) report losses in sucrose as well as tonnage. In this work with Merker grass the chlorotic streak disease delayed maturity. Possibly, chlorotic streak disease of sugarcane upsets normal maturation under some conditions, and in this way lowers sugar yield. Until transmission studies have been made to determine the possible relationships between the chlorotic streak diseases of Merker grass and sugarcane, the observational evidence of their similarities seems strong enough to warrant proceeding on the assumption that they are caused by the same virus. Chlorotic streak-control programs in both hosts should advance together for the greatest safety.

RESUMEN

La enfermedad de la raya clorótica de la yerba Merker (*Pennisetum purpureum* Schumac) tiene muchos rasgos en común con la raya clorótica de la caña de azúcar. Los síntomas que presentan las hojas son similares. Ambas enfermedades pueden ir en la semilla y también ambas pueden evitarse si se sumerjen las semillas afectadas en agua caliente (52°C.) por 20 minutos.

La yerba enferma con la raya clorótica se encontró, corrientemente, cerca de caña enferma con raya clorótica, o pudo localizarse el sitio de donde provenía la enfermedad que era también donde la caña estaba enferma. La infección en ambas cañas (1, 6) y en la yerba causó grandes pérdidas en el tonelaje. Algunos experimentos con caña de azúcar (1, 6) revelaron pérdidas en sacarosa y en tonelaje.

En este trabajo con yerba Merker se encontró que la enfermedad de la raya clorótica retardó la madurez. Posiblemente, la enfermedad de la raya clorótica en la caña de azúcar trastorna su madurez normal bajo ciertas condiciones y de esta manera disminuye los rendimientos de azúcar.

No sería hasta que se hagan estudios de transmisión para determinar la posible relación entre las enfermedades de la raya clorótica que atacan la caña y la yerba Merker, que la evidencia de su semejanza podría garantizar firmemente el poder seguir suponiendo que ambas son causadas por el mismo virus.

El control de ambas enfermedades, tanto en la caña de azúcar como en la yerba Merker, deben propulsarse a la vez como medida de seguridad.

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Filter-Press Cake as a Fertilizer

George Samuels and Pablo Landrau, Jr.[1]

INTRODUCTION

Every year the sugarcane mills of Puerto Rico produce large quantities of a byproduct called filter-press cake or filter-press mud. An average of 60 pounds of filter-press cake is produced for every ton of sugarcane milled. Assuming an output of 12,000,000 tons of millable cane per year, Puerto Rico has an annual production of about 360,000 tons of filter-press cake to utilize. This dark-brown to black organic material is usually dumped on or near the premises of the factory where it accumulates in piles covering many acres. It is often used in fertilizing nearby sugarcane fields. The rates used are very high and applications up to 100 tons per acre are not rare.

Some filter-press cake has been used by home gardeners as a topdressing for lawns and gardens. The material has also found use in vegetable plantings and on pineapple plantations. However, no specific rate or method of application has so far governed its general use in farm practice.

Very limited information is available in the literature concerning the use of filter-press cake in agriculture. Aside from work by Ramírez (5),[2] Riollano (6), and Hernández-Medina, *et al.* (1–3), most of the reports that have appeared deal mainly with observed results rather than experimental proof.

Beginning in 1949, fertilizer experiments were carried out by the authors on some of the leading economic agricultural crops of Puerto Rico in which results of the use of filter-press cake were compared with those obtained with inorganic commercial fertilizers. It is the object of this paper to report the results of these various experiments in which filter-press cake was used as a fertilizer material. The value of this material as a fertilizer will be discussed and practical recommendations will be made as to its use.

PHYSICAL AND CHEMICAL PROPERTIES OF FILTER-PRESS CAKE

Filter-press cake consists principally of a mixture of sugarcane fibers, sucrose, coagulated colloids including cane wax, albumoids, and phosphates of lime, plus sand and soil. Most of the constituents come from the ground-up sugarcane. The lime is added in the process of neutralizing and clarifying

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[2] Numbers in parentheses refer to Literature Cited, p. 213.

the cane juice, and the sand and soil enter as foreign matter clinging to the cane.

Physically, filter-press cake is a soft, spongy, lightweight amorphous dark-brown to black material. It can readily absorb large quantities of moisture when dry. It generally contains from 55 to 70 percent of moisture on a wet basis when taken fresh from the factory. When allowed to air-dry the moisture content averages about 15 percent. Its volume-weight is very low, being only 0.375 on a dry-weight basis, and about 0.57 at 65-percent moisture. Thus 1 ton of filter-press cake at 65-percent moisture (wet basis) would occupy about 56 cubic feet, or approximately 2 cubic yards.

Filter-press cake varies somewhat in chemical composition, depending upon such factors as the cane varieties being ground, the area where cane is grown, the climate, and mill performance. The range and mean values for the various chemical constituents of filter-press cake are given in table 1. These values represent many samples of filter-press cake taken from sugarcane mills from all of the cane-growing areas of Puerto Rico.

TABLE 1.—*The chemical composition and physical properties of filter-press cake*[1]

Constituent	Samples	Composition on a dry-weight basis	
		Average	Range of values
	Number	*Percent*	*Percent*
Nitrogen (N)	43	2.19	1.07–3.13
Phosphorus (P_2O_5)	43	2.77	1.34–6.30
Potassium (K_2O)	41	.44	.02–1.77
Calcium (CaO)	42	3.05	.98–6.24
Magnesium (MgO)	2	.49	.42–.58
Manganese (MnO_2)	6	.17	.10–.24
Iron (Fe_2O_3)	6	1.05	.26–4.71
Boron (B_2O_3)	4	.01	.00–0.02
Organic matter	1	39.5	—
Loss in ignition	1	45.2	—
Sucrose	4	3	2–4
Moisture[2] (fresh)[3]	18	61	56–69
Moisture[2] (stored)[4]	23	15	9–47
Volume-weight[5]	2	.375	.372–.378

[1] Based on the analysis of samples taken by the authors, plus some given in literature (3, 5, 6).

[2] Calculated on a wet basis.

[3] Fresh material taken from the Oliver and press filter at the mill.

[4] Material taken from the dump piles near the mills where it had been exposed to the weather.

[5] Calculated on a dry-weight basis and expressed in cubic centimeters per gram.

Of the major plant nutrients (N-P-K), filter-press cake is highest in phosphorus as P_2O_5, nitrogen being generally a bit lower. The average values are 2.19 percent for N and 2.77 percent for P_2O_5, with fluctuations between 1.07 to 3.13 percent for N and between 1.34 to 6.30 percent for P_2O_5. The nitrogen occurs mainly as protein and in other complex forms rather than as the less complex ammonia or nitrate forms. However, conversion to these simpler forms proceeds very rapidly as the filter-press cake decomposes. Phosphorus is present in the form of complex organic combinations such as phospholipids and nucleoproteins. Some phosphorus is also present as calcium phosphates which were formed when the lime was added in the process of clarification. Usually most of the phosphorus is present in organic complexes which decompose readily to supply considerable available phosphorus for plant use.

The potassium content of filter-press cake is low. It averages 0.44 percent as K_2O with a range from 0.02 to 1.77 percent—the higher figure being extremely rare. Inasmuch as potassium is not known to be fixed in the cane plant in any complex organic form, that present is extracted in the juice and by the water added in the milling process, and most of it is found in the molasses. The ash of molasses contains about 32 percent of K_2O (5). The small quantity of potash present in the filter-press cake is in a soluble, very easily leached form.

The calcium content of filter-press cake is high and averages about 3 percent as CaO. Most of the calcium is derived from the lime added when processing the sugarcane rather than from the plant itself.

Minor elements such as magnesium, manganese, iron, and boron are present in the filter-press cake in fair amounts—enough to make it a good source of minor elements for use by the plants. The iron content of filter-press cake averages about 1 percent. All of this iron may not be in readily available form, as some is found in the soil which forms part of the foreign matter, and part occurs as traces of metallic iron derived from the machinery used in the grinding of the cane.

EXPERIMENTAL RESULTS

In the experiments with filter-press cake as a fertilizer such crops as sugarcane, vegetables, tobacco, and root crops were utilized. The results obtained are reported under the individual crops.

SUGARCANE

The bulk of the filter-press cake used as fertilizer was applied to sugarcane. The results obtained from this material were not outstanding. As can be seen in table 2, cane yields were not appreciably increased where filter-press cake was used. It is to be remembered, however, that commercial

TABLE 2.—*Relative sugarcane yields for 4 soils receiving commercial cane fertilizers and filter-press cake*

Soil	Fertilizer treatment, per acre, of—				Relative sugarcane yields per acre		
	Commercial inorganic fertilizer as—			Filter-press cake[1]	Tons of cane	Sucrose	Available 96° sugar
	N	P_2O_5	K_2O				
	Pounds	*Pounds*	*Pounds*	*Tons*	*Percent*	*Percent*	*Percent*
Santa Isabel silty clay (irrigated)[2]	176	16	40	0	100	100	100
	176	16	40	10	84	108	92
Santa Isabel silty clay (unirrigated)[3]	250	0	300	0	100	100	100
	250	0	300	20	94	102	96
	0	0	0	20	97	96	93
	0	0	0	40	93	95	87
	0	0	0	60	82	97	80
Coto clay[4]	250	300	300	0	100	100	100
	250	300	300	10	103	100	104
Lares clay[5]	300	300	300	0	100	100	100
	300	300	300	20	112	101	111
Vía silty clay[6]	300	300	300	0	100	100	100
	300	300	300	10	103	99	101

[1] Filter-press-cake rates calculated on a wet basis.

[2] Plant cane, 1950–52, B. 34104 at Central Cortada, Aguirre.

[3] Plant cane and 2 ratoons, 1950–54, P. O. J. 2878 at Lajas Substation.

[4] First and second ratoons, 1950–52, P. R. 902 at Colonia Irurena, Isabela.

[5] Plant cane and 2 ratoons, 1951–54, P. R. 905 at Corozal Substation.

[6] First and second ratoons, 1952–54, P. O. J. 2878 at Colonia Santa Teresa, Humacao.

fertilizer was used along with the filter-press cake in most of the experiments. It, therefore, seemed wasteful to apply any appreciable quantity of filter-press cake to a field to which commercial fertilizer had just been applied.

It is interesting to note that the filter-press cake not only failed to increase yields on unirrigated Santa Isabel silty clay, but actually decreased them with increasing rates of application of filter-press cake in the absence of inorganic fertilizers (see table 2).

Because large quantities of inorganic material are returned to the soil by the cane trash (7), much of the beneficial influence of filter-press cake is lost as a soil ammendment in controlling soil moisture, aeration, and temperature. The filter-press cake is beneficial to soils requiring nitrogen

and phosphorus. However, where potash requirements are high, the use of filter-press cake only may not guarantee an adequate supply of potassium for the cane.

VEGETABLE CROPS

Filter-press cake has always found favor among our farmers in growing vegetables. Its widest usage has been for the home garden and small vegetable plots of usually less than 1 acre.

Tomatoes

As shown in table 3, filter-press cake increased the yields of tomatoes. When used alone, 20 tons of filter-press cake gave no significantly higher yields than did 10 tons per acre. No significant response in yield was obtained with the use of 10 or 20 tons of filter-press cake in conjunction with commercial fertilizer, as compared with commercial fertilizer alone (table 3, treatments 5 and 6 compared with 4). There was a need for nitro-

TABLE 3.—*Influence of filter-press cake and commercial fertilizers on yields of tomatoes and peppers*

Treatment No.	Fertilizer treatments, per acre of—				Yields of produce per acre	
	Commercial inorganic fertilizer as—			Filter-press cake[1]	Tomatoes[2]	Peppers[3]
	N	P_2O_5	K_2O			
	Pounds	*Pound*	*Pounds*	*Tons*	*Cwt.*	*Cwt.*
1	0	0	0	0	37.5	33.0
2	0	0	0	10	68.6	57.0
3	0	0	0	20	84.0	52.5
4	100	200	200	0	136.4	48.6
5	100	200	200	10	135.0	86.2
6	100	200	200	20	158.9	77.9
7	0	200	200	0	80.5	60.4
8	200	0	200	0	84.7	30.0
9	200	200	0	0	145.5	62.7
Least significant difference needed between treatments at:						
5-percent level					30.9	22.6
1-percent level					41.1	30.0

[1] Calculated on a wet basis.

[2] Data taken from experiment conducted at the Isabela Substation, 1952–53, on a Coto clay with Plamar variety of tomato.

[3] Data taken from experiment conducted at Aibonito, 1952–53, on a Juncos clay with a Puerto Rico Wonder variety of pepper.

gen (treatment 4 compared with 7), and for phosphorus (treatment 4 compared with 8), but not for potassium (treatment 4 compared with 9).

It is of interest to note that inorganic fertilizers alone gave greater yields of tomatoes than did filter-press cake only (treatment 4 compared with treatments 5 and 6). Riollano (6), working with tomatoes in the same soil, Coto clay, obtained a significant increase in yield by using 12 tons of filter-press cake, plus 1,000 pounds of 8–10–15 fertilizer.

Peppers

The use of filter-press cake at the rate of 10 tons per acre (table 3, treatment 2 minus treatment 1), increased yields of peppers, but 20 tons did not as compared with 10 tons per acre. The use of 10 tons per acre of filter-press cake in combination with commercial fertilizer also increased yields above those obtained with the commercial fertilizer alone (treatment 5 less treatment 4). No greater yield increases were obtained when 20 tons of filter-press cake were used instead of 10 along with the inorganic fertilizer.

Pigeon peas

Filter-press cake was applied at a rate of 20 tons per acre to pigeon peas growing on a Coto clay at the Isabela Substation, 1953–54. The results of the harvests for 2 years showed no yield response, nor did yields respond to the use of various inorganic fertilizers containing nitrogen, phosphorus, or potassium. It appears that the pigeon pea was able to obtain sufficient available nutrient supply from the soil without fertilizer applications.

Corn

Mayorbela corn grown at the Lajas Substation on a Santa Isabel clay was fertilized with ammonium sulfate and also with filter-press cake in amounts equivalent to 120 pounds of N per acre. There was no significant response in yield to either.

TOBACCO

Filter-press cake was used as a fertilizer in a tobacco fertilizer experiment at Aibonito on a Juncos clay. The results obtained are given in table 4. When filter-press cake was applied as a nitrogen source using rates equivalent to the nitrogen applied in the form of ammonium sulfate (treatment 3), there was a significant increase over the no-nitrogen treatment (treatment 1). However, yield increases were significantly higher when ammonium sulfate was used as the nitrogen source (treatment 2 compared with treatment 3). When one-half of the nitrogen was in the form of

TABLE 4.—*Influence of filter-press cake and commercial fertilizers on yields of tobacco*[1]

Treatment No.	Fertilizer treatment per acre of—				Yield of tobacco per acre			
	Commercial inorganic fertilizer as—			Filter-press cake[2]	First crop, 1951–52	Second crop, 1952–53	Third crop, 1953–54	Mean of 3 crops
	N	P_2O_5	K_2O					
	Pounds	*Pounds*	*Pounds*	*Tons*	*Cwt.*	*Cwt.*	*Cwt.*	*Cwt.*
1	0	100	150	0	6.34	8.26	8.77	7.99
2	100	100	150	0	12.38	10.50	20.60	14.49
3	0	100	150	2.5[3]	9.55	10.52	14.01	11.36
4	50	100	150	1.25[4]	11.57	8.61	17.51	13.20
5	150	0	150	0	10.80	10.29	13.50	10.97
6	150	100	0	0	12.43	10.00	18.33	13.68
7	0	100	150[5]	2.5[3]	—	11.19	15.01	—
8	100	100	150[5]	0	—		23.90	—
Least significant differences needed between treatments at:								
5-percent level					2.17	1.31	3.29	2.26
1-percent level					2.81	1.71	4.34	2.95

[1] Virginia 12 variety of tobacco grown on a Juncos clay at Aibonito.

[2] Calculated on a dry-weight basis.

[3] The 2.5 tons of filter-press cake (2-percent N) used was calculated to contain 100 lb. of N.

[4] The 1.25 tons of filter-press cake (2-percent N) used was calculated to contain 50 lb. of N.

[5] Lime was applied at the rate of 2 tons of $CaCO_3$ per acre.

ammonium sulfate and one-half was derived from filter-press cake (treatment 4), the yields were comparable to those obtained when ammonium sulfate only was used. Inasmuch as tobacco is a short-growing crop requiring only a few months to attain maturity, it appears that the decomposition of filter-press cake is not sufficiently rapid in this soil to supply the crop's heavy immediate demand for nitrogen.

Phosphorus was also needed by tobacco, but no significant yield increases were obtained from potash applications.

The highest tobacco yields were obtained when lime was used with inorganic fertilizer (treatment 8). However, when filter-press cake was substituted to supply nitrogen equivalent to that supplied by ammonium sulfate, no such yield increase with the addition of lime was noted (treatment 7).

At present no explanation can be offered for this failure of increasing yields significantly when lime is used in conjunction with filter-press cake.

TABLE 5.—*Influence of filter-press cake and commercial fertilizer on the yields of root crops*

Treatment No.	Fertilizer treatment per acre of—				Yield of root crops per acre		
	Commercial inorganic fertilizer as—			Filter-press cake[1]	Yams[2]	Sweetpotatoes[3]	Yautías (dasheen)[4]
	N	P_2O_5	K_2O				
	Pounds	*Pounds*	*Pounds*	*Tons*	*Cwt.*	*Cwt.*	*Cwt.*
1	0	0	0	0	231	—	—
2	225	100	225	0	249	—	—
3	225	100	225	15	239	—	—
4	0	0	0	10	—	29	33
5	0	0	0	20	—	31	53
6	183	200	200	0	—	47	—
7	83	100	100	10	—	57	—
8	100	200	200	0	—	—	19
9	100	200	200	10	—	—	51
10	100	200	200	20	—	—	53
Least significant differences needed between treatments at:							
5-percent level					38	14	18
1-percent level					—	19	23

[1] Calculated on a wet basis.

[2] White Guinea yam, (*Dioscorea rotundata*), grown at Utuado on a Lares clay, 1951–52.

[3] U.P.R. 3, yellow-fleshed sweetpotato grown at Loíza on a Cataño loamy sand, 1950.

[4] Kelly yautía (*Xanthosoma atrovirens*), grown at the Corozal Substation on a Lares clay, 1953.

ROOT CROPS

Yams

The White Guinea variety of yam, *Dioscorea rotundata*, was grown on a Lares clay at Utuado with applications of filter-press cake. The results in table 5 show no significant yield response to either filter-press cake or mixed fertilizer.

Sweetpotatoes

Filter-press cake failed to increase sweetpotato yields on a Cataño loamy sand when used alone or in conjunction with a mixed fertilizer. The use of 10 tons of filter-press cake per acre, plus a mixed fertilizer (table 5, treatment 7), gave no significantly increased yields over those obtained

with mixed fertilizers alone (treatment 6). Yield increases were not marked when filter-press cake was used alone (treatments 4 and 5). This soil responded to potash fertilizers. Filter-press cake lacked sufficient potash to produce high sweetpotato yields when used alone, but high yields were realized when it was combined with inorganic fertilizers to supply extra potash. Sweetpotatoes have a high demand for potash (2); if filter-press cake is to be used as a fertilizer for this crop it must be reenforced with additional potash.

Yautías

Yautías, *Xanthosoma atrovirens*, Kelly variety, were fertilized with filter-press cake on the heavy Lares clay at Corozal. The use of it alone, or in combination with inorganic fertilizers, increased yields significantly as compared with the use of inorganic fertilizers only (table 5). Filter-press cake gave higher yields at 20 than at 10 tons per acre, when used alone. In combination with inorganic mixed fertilizer, 20 tons per acre of filter-press cake proved to be no better than 10. The yautías did not respond to potash applications in this experiment.

PLANTAINS

Filter-press cake did not prove beneficial to plantains grown at the Corozal Substation on a Lares Clay, 1950–51. The use of 10 tons of filter-press cake, plus 2,000 pounds of a 10–10–10 commercial fertilizer per acre, gave no increase in yield over that obtained with the use of 2,000 pounds of the 10–10–10 fertilizer alone. The soil received an application of 7,500 pounds of lime ($CaCO_3$) per acre. Yields were reduced from 22 pounds of plantains per tree with commercial fertilizer to 16 pounds with fertilizer plus filter-press cake.

PINEAPPLES

The influence of filter-press cake on pineapple yields must be re-evaluated in light of our newly acquired knowledge of the limiting factors imposed by biological-parasitic factors on pineapple growth. Experiments conducted before adequate measures were taken to control soil nematodes, mealybugs, and other biological-parasitic factors produced variable results. Hernández-Medina, *et al.* (1) found that on a Bayamón silty clay at Manatí, 1951–53, the use of 20 tons of filter-press cake per acre, plus, 2,500 pounds of a 12–6–8 mixed fertilizer, gave no increase in yields over the mixed fertilizer used alone. On a Bayamón silty clay at Palo Blanco, Arecibo, 1950–51, there were no significant yield increases when up to 32 tons of filter-press cake per acre were applied without mixed fertilizers (1). However, the use of 32 tons of filter-press cake, plus 1,500 pounds of a 12–6–10

formula, gave yields just as good as those obtained with 3,000 pounds per acre of a 12–6–10 fertilizer. A combination of 30 tons of filter-press cake and 3,000 pounds of a 12–6–10 formula was needed to produce the highest yields on a heavy Lares clay. Filter-press cake alone was insufficient.

When the soil and pineapple plants were properly treated with fumigants and insecticides to control biological-parasitic factors, filter-press cake at the rate of 20 tons per acre failed to increase yields on a Bayamón silty clay.

DISCUSSION

Filter-press cake has value as a fertilizer. However, as it is not concentrated, much more of it must be used than of inorganic mixed commercial fertilizers. But its nutrient concentration is sufficient to allow it to compete with organic fertilizer sources such as animal manures. In table 6 a comparison is made of the fertilizer composition of filter-press cake and regularly used organic fertilizer materials. Except for its lower potash content, filter-press cake's fertilizer value is greater than that of animal manures, but it does not have as good a composition as the seed meals and animal tankages. Because of high shipping rates on imports of the bulky organic fertilizer materials, filter-press cake can be used to replace these at quite a saving in transportation costs.

When applied directly from the factory to field or garden, filter-press cake will "burn" the plants like fresh animal manure. This so-called "burning" really results from the rapid decomposition of the new filter-press

TABLE 6.—*A comparison of the chemical composition of filter-press cake, manures, and other organic-fertilizer sources*[1]

Fertilizer material	Composition on a dry-weight basis as—		
	N	P_2O_5	K_2O
	Percent	*Pounds*	*Percent*
Filter-press cake	2.2	2.8	0.5
Cattle manure, shredded	2.0	1.8	2.2
Sheep or goat manure	1.4	1.0	3.0
Castor pomace	4.1–6.6	1–2	1–1.5
Cottonseed meal	6.7–7.4	2–3	1.5–2
Fish tankage	6.5–10	4–8	—
Garbage tankage	2.5–3.3	2–5	.5–1
Sewage sludge (activated)	4.1–6.4	2.5–4	—
Tankage (animal)	5–10	3–13	—
Tobacco stems	1.2–3.3	—	4–9

[1] Chemical composition of the manures and other organic-fertilizer sources adopted from (4).

cake which liberates heat and ammonia and other nutrients in high concentrations. Many farmers allow filter-press cake to "cure", or to complete its initial decomposition, from 6 months to 1 year before using. However, this curing is not necessary for use on field crops if the fresh filter-press cake is applied sufficiently (about 6 weeks) in advance of planting. It will then have had time to complete its initial decomposition and will prove equal to well-rotted filter-press cake.

Filter-press cake has very little residual action on the soil. It decomposes quite rapidly, releasing the bulk of its nitrogen as nitrates. The peak of nitrate formation occurs in about 5 months after it is applied to the soil (see fig. 1). The low residual action of filter-press cake was shown very clearly in Ramírez's work (5) where different quantities up to 75 tons per acre produced appreciable yield increases in the plant cane, but failed to do so for the first ratoon crop, and proved less beneficial still to the second ratoon crop.

The authors personally have seen applications of filter-press cake as high as 200 tons or more per acre on a sandy soil fail to produce any influence 1 year thereafter. Unlike lime, filter-press cake does not produce a strong residual effect over a long period of time. The maximum organic matter a soil will contain under natural conditions is controlled by certain natural laws governing the soil and climate; the addition of amounts over this maximum will be wasteful in that the material added will be rapidly de-

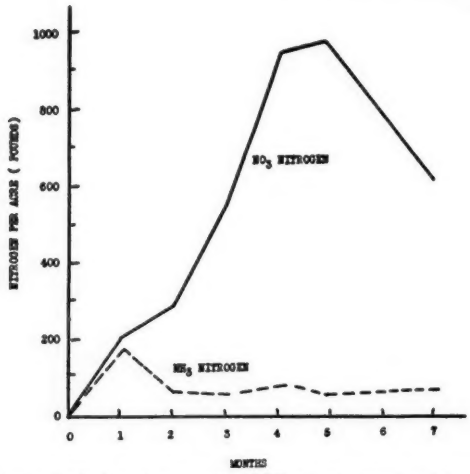

FIG. 1.—Nitrate (NO_3) and ammonia (NH_3) nitrogen produced per acre over a 7-month period when 15 tons of filter-press cake per acre were added to a soil (after Ramírez (5)).

stroyed by the soil microflora until the natural level is reached. Therefore, unnaturally high organic levels cannot be maintained in the soil by using filter-press cake.

When filter-press cake is available from a nearby local source, its main cost is that of transportation and application. Because of its great bulk, these costs may be high for large applications. Fresh filter-press cake contains about 60 percent of moisture by weight and even when piled at the factory and allowed to stand, the moisture runs from 15 to 45 percent. Because of its high moisture content and variations caused by place and method of storage, filter-press cake applications will vary greatly in their nutrient content.

For example, a truck of 5 cubic yards capacity can haul about 2.3 tons per load of fresh filter-press cake containing 60-percent moisture by weight. This represents about 40 pounds of N, 50 of P_2O_5, and 8 of K_2O per acre. An application of 15 tons of filter-press cake (6½ truckloads) to an acre of cane land would mean that the cane would receive in fertilizer material equivalents of about 250 pounds of N, 325 of P_2O_5, and 50 of K_2O. Filter-press cake of 30-percent moisture content weighs about 1.9 tons per 5 cubic yards and it would require 8 truckloads to deliver 15 tons to a field. But now more nutrients and less water are present, so that 1 acre of cane receiving

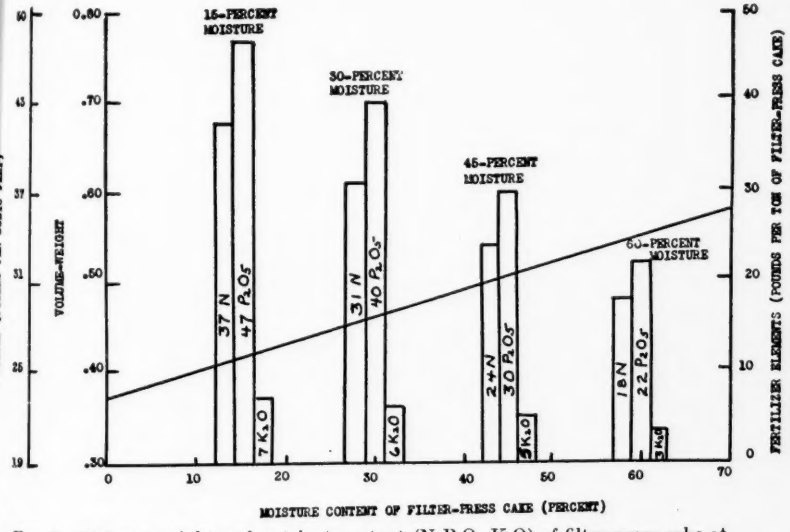

FIG. 2.—Volume-weight and nutrient content (N-P_2O_5-K_2O) of filter-press cake at various moisture contents.

the 15 tons of 30-percent-moisture filter-press cake would get about 450 pounds of N, 600 of P_2O_5, and 100 of K_2O.

To facilitate calculations of the volume or weight of filter-press cake at various moisture contents, figure 2 has been constructed from experimental measurements. The N, P_2O_5, and K_2O contained in 1 ton of filter-press cake at certain moisture contents are also presented therein as a guide to the use of this material.

In any discussion of filter-press cake it should be mentioned that it is a perfect medium for breeding insects. To kill flies, ants, and other insects usually present when filter-press cake is being handled, spray it with chlordane or aldrin. This does not interfere with its fertilizing properties at all.

SUMMARY

This study on the use of filter-press cake as a fertilizer material may be summarized as follows:

1. It is a byproduct of the sugarcane mills consisting principally of a mixture of cane fibers, sucrose, coagulated colloids including cane wax, albumoids, and phosphates of lime, plus sand and soil.

2. It is a soft, spongy, lightweight, amorphous dark-brown to black material. When fresh from the filter-presses it contains about 60 percent of moisture, and about 15 percent when air-dry.

3. Its chemical composition averages 2.19 percent of N, 2.77 percent of P_2O_5, 0.44 percent of K_2O, and 3.05 percent of CaO, plus considerable quantities of the minor elements.

4. It did not produce appreciable yield increases when used on sugarcane in combination with commercial mixed inorganic fertilizer.

5. It was beneficial to tomatoes growing on a Coto clay when used at a rate of 10 tons per acre, but yields were higher when commercial fertilizer was used.

6. Ten tons per acre significantly increased yields of peppers on a Juncos clay.

7. Pigeon peas and corn responded to neither filter-press cake nor regular fertilizers.

8. Tobacco yielded more when filter-press cake was used as a nitrogen source, but ammonium sulfate produced higher yields still when used to supply equivalent amounts of N.

9. Yams did not respond to the use of filter-press cake.

10. Filter-press cake alone did not produce as good results on sweetpotatoes as commercial fertilizer.

11. Filter-press cake increased the yield of yautías.

12. Plantains did not respond to filter-press cake when grown on a Lares clay.

13. Pineapples gave a mixed response to applications of filter-press cake. When damage caused by biological-parasitic factors was properly controlled, the filter-press cake applications did not increase yields.

14. The composition of filter-press cake, as compared with that of other organic fertilizers showed it to be about equal (except for low K_2O) to animal manures but not to animal tankage or seed meals.

15. If applied about 6 weeks prior to planting, the decomposition of fresh filter-press cake will not produce "burning" on vegetable crops.

PRACTICAL RECOMMENDATIONS

Filter-press cake may be used advantageously as a fertilizer material if adequate attention is paid to its limitations and full use is made of its particular advantages. Its main disadvantages are its low K_2O content and large bulk combined with low concentrations of nutrients. Its main advantages are its cheapness, slower release of nutrients, minor-element content, high water-holding capacity, high exchange capacity, and mulching properties.

The following recommendations are made for its use on crops:

1. Apply yearly in small amounts rather than in very large applications once in 3 to 4 years.

2. Use more on light-textured soils, than on heavy clays.

3. Use carefully on very poorly drained soils, not applying the filter-press cake too deeply in the soil, which prevents proper decomposition.

4. Large applications must undergo thorough incorporation into the plowed layer. Surface application and incorporation with the upper inch or two of soil is better for small applications. For root crops, application in the hole below the seed makes better use of minimum quantities.

5. Filter-press cake should be applied to fast-growing crops such as vegetables and tobacco a few weeks before planting, especially if the filter-press cake is not well rotted.

6. Filter-press cake should be supplemented with potash fertilizer when used for crops or soils with high potash demands, about 30 pounds of KCl for every ton of fresh filter-press cake containing 60 percent of moisture.

7. The maximum yearly recommendations in tons per acre for specific crops are: Sugarcane 10, pineapple 30, root crops 20, ornamentals 10 to 20, coffee 20, tobacco 10, vegetables 10, and plantains 10.

RESUMEN

Este estudio sobre el uso de la cachaza como materia fertilizante puede resumirse como sigue:

1. La cachaza es un producto secundario resultante de la elaboración del azúcar en las centrales azucareras, el cual consiste de una mezcla de fibra,

sacarosa, coloides coagulados incluyendo la cera de la caña, albuminoides, fosfatos de cal, y arena y tierra.

2. Es una materia amorfa, de color marrón obscuro a negro, blanda, esponjosa y liviana.

3. Su composición química tiene el porcentaje promedio siguiente: 2.19 de N; 2.77 de P_2O_5; 0.44 de K_2O; 3.05 de calcio y cantidades considerables de elementos menores.

4. Cuando se usa en combinación con los fertilizantes comerciales mezclados, no produce aumentos apreciables al aplicarse a la caña de azúcar.

5. Es muy beneficiosa para el tomate que se siembra en arcilla Coto, si se aplica a razón de 10 toneladas por acre, aunque se ha conseguido aumentar los rendimientos cuando se combinó con abonos comerciales.

6. En arcilla Juncos se logró aumentar significativamente los rendimientos del pimiento cuando se usó a razón de 10 toneladas por cuerda.

7. El gandul y el maíz no respondieron a las aplicaciones de cachaza ni a los abonos comerciales.

8. El tabaco rindió más cuando se le aplicó cachaza como fuente principal de nitrógeno, pero el sulfato amónico ejerció mejor efecto, en cuanto a aumentar los rendimientos, cuando se usó para suplir cantidades equivalentes de nitrógeno.

9. El ñame no respondió a las aplicaciones de cachaza.

10. La cachaza sola, aplicada a la batata, no produjo tan buenos resultados como cuando se le aplicó abono comercial a esta cosecha.

11. La cachaza aumentó los rendimientos de la yautía.

12. El plátano no respondió a las aplicaciones de cachaza en la arcilla de Lares.

13. La piña no respondió en forma conclusiva a las aplicaciones de cachaza. Se observó que cuando el daño a las plantas, causado por factores bioparasíticos, fué debidamente controlado, las aplicaciones de cachaza no aumentaron los rendimientos.

14. Al compararse la composición química de la cachaza con la de otras materias orgánicas fertilizantes se encontró que era casi igual (exceptuando su menor cantidad de K_2O) que los estiércoles de origen animal, pero diferente al tancaje animal y a las harinas de semillas.

15. Aplicándose al terreno seis semanas antes de la siembra, se encontró que la cachaza fresca no quemó las plantas recien sembradas.

RECOMENDACIONES PRACTICAS

La cachaza puede usarse remunerativamente como materia fertilizante si se presta adecuada atención a sus limitaciones, a la vez que se aprovechan sus peculiares ventajas. Está limitada por un contenido bajo de K_2O, y su volumen es relativamente enorme si se considera las concentraciones bajas

de nutrientes que contiene. Sin embargo, sus ventajas contrapesan estas limitaciones. Es barata; sus elementos fertilizantes no se pierden con facilidad; tiene un alto contenido de elementos fertilizantes menores; su capacidad para retener la humedad es considerable, al igual que la de intercambio y además posee propiedades excelentes como materia cobertora.

Se hacen las siguientes recomendaciones sobre el uso de la cachaza para las cosechas:

1. Aplíquese anualmente en pequeñas cantidades, en vez de en cantidades proporcionalmente mayores cada 3 ó 4 años.
2. Usese mayor cantidad en los suelos livianos que en los arcilloso pesados.
3. En suelos con desagüe difícil hay que aplicarla con cautela de manera que no queda muy hondà, lo cual evita su descomposición normal.
4. Si se aplica en grandes cantidades debe incorporarse bien al terreno durante su preparación. Si se aplica a la superficie del terreno para incorporarse a una pulgada o dos, es mejor usar pequeñas cantidades.
5. Para cosechas de rápido desarrollo, como son el tabaco y las hortalizas, la cachaza debe ponerse algunas semanas antes de la siembra, especialmente si aún no está bien descompuesta.
6. Es necesario suplementar la cachaza con potasa cuando las cosechas o los suelos exijan un alto contenido de este elemento fertilizante. Cerca de 30 libras de KCl por cada tonelada de cachaza fresca, con 60 por ciento de humedad, serán suficientes.
7. Las cantidades máximas anuales, en toneladas de cachaza por acre, recomendadas para cosechas específicas son: Caña de azúcar 10, piña 30, tubérculos 20, plantas ornamentales de 10 a 20, café 20, tabaco 10, hortalizas 10, y plátanos 10.

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A Catalogue of the Bloodsucking Midges of the Americas (*Culicoides, Leptoconops,* and *Lasiohelea*) with Keys to the Subgenera and Nearctic Species, a Geographic Index, and Bibliography

Irving Fox[1]

INTRODUCTION

The last complete list of *Culicoides* (Vargas, 1949b)[2] included 30 Nearctic and 60 Neotropical species; but so great has been taxonomic activity during the past 5 years that many more species are known today. By the end of June 1954 a total of 198 trivial names had been used for *Culicoides* of the Western Hemisphere, of which 14 pertain to species belonging in other genera and at least 24 are synonyms. In *Leptoconops* 12 names have been used of which 3 are synonyms; and 12 names have also been proposed in *Lasiohelea.*

Recently attempts have been made to divide *Culicoides* into subgenera. The system which follows differs from two previous efforts, those of Khalaf (1954) and Vargas (1953a), in that primary emphasis for separation of the subgenera is placed on the male terminalia. It is possible in this way to retain Khalaf's name *Monoculicoides* even though he included in this subgenus the type of Vargas' *Beltranmyia.* Vargas erected *Beltranmyia* for a small group of species related to *crepuscularis* Malloch, but since the males differ from others only in having a reduced ventral root, it is deemed desirable to use the subgeneric name for a much larger group of species. It has not been possible to place in subgeneric synonymy two names which have been considered synonyms of *Culicoides, Synhelea* Kieffer (1925a), which was based on two species never again found, and *Cotocripus* Brèthes (1912), which was based on *caridei,* a disputed species placed in *Culicoides* by some authors and in *Dasyhelea* by others. *Caridei* is here included among those Neotropical species whose males have not been described which probably belong in either *Oecacta* or *Beltranmyia.*

LITERATURE REVIEW

It is the general opinion today that only three of the genera of Ceratopogonidae occurring in the Western Hemisphere include members which suck mammalian blood; these are *Culicoides, Leptoconops,* and *Lasiohelea.* In 1915, Townsend erroneously postulated that two species of *Forcipomyia,*

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[2] For references see Bibliography, pp. 270–85.

utae Knab and *townsendi* Knab, both described in 1915, were the vectors of American leishmaniasis. Edwards (1922) and Goetghebuer (1923, 1935) indicated that any records of biting by *Forcipomyia*, *Atrichopogon*, or *Dasyhelea* are very likely in error. The bloodsucking midges affect man's welfare by causing severe annoyance from their bites, to which certain individuals react very strongly (Dampf, 1936a; Hase, 1933; Jobling, 1928; Leclercq, 1950; Mandoul, 1926) and by transmitting human and animal diseases. They are the proven vectors of three human nematodes, *Acanthocheilonema perstans* (Garnham and Harper, 1944; Hopkins, 1952; Hopkins and Nicholas, 1952; Kershaw, 1950; Nicholas, 1953a, Nicholas, *et al.*, 1953; Roman, 1941; Sharp, 1927, 1928); *Acanthocheilonema streptocerca* (Chardome and Peel, 1949; Henrard and Peel, 1949; Van Den Berghe and Chardome, 1952); and *Mansonella ozzardi* (Briceño-Rossi, 1949; Buckley, 1933, 1934a, 1934b; O'Connor, 1937; Romaña and Wygodzinsky, 1950); but not of *Onchocerca volvulus* (Gibson and Ascoli, 1952). Various authors have suspected them to be vectors of fevers of undetermined origin (Huttel, *et al.*, 1953; Loughnan, 1921; Purcell, 1937; Stephens, 1923; Wanson, 1939). As regards animal diseases, they transmit equine and bovine onchocerciasis (Buckley, 1938; Moignoux, 1951; Steward, 1933, 1935; Wehr and Lucker, 1952), African horse sickness and blue tongue of sheep (Bradley, 1954; Du Toit, 1944, 1945), and a filaria of frogs (Desportes, 1941, 1942). On several occasions unidentified filariae have been found in them (Causey, 1938; Dampf, 1936a; Hoffman, 1939; Mirsa, *et al.*, 1952; Sergent, *et al.*, 1933; Vargas, 1941).

A number of workers have dealt with the morphology of the adult (Goetghebuer, 1923; Jobling, 1928; Leon, 1924; Mukerji, 1931a, 1931b; Pomerantzev, 1932; Snodgrass, 1943; Tokunaga, 1937) and of the immature stages (Anderson, 1937; Carter, *et al.*, 1920; Dove, *et al.*, 1932; Fox, 1942; Goetghebuer, 1919; Goetghebuer and Lenz, 1934; Hill, 1947; Hoffman, 1924; Jobling, 1929, 1953; Kettle and Lawson, 1952; Lawson, 1951; Mayer, 1934; Medwedewa, 1927; Painter, 1926; Parker, 1950; Patel, 1921; Patton, 1913; Rieth, 1915; Smith and Lowe, 1948; Thienemann, 1928; Thomsen, 1937; Williams, 1951a, 1951b; Wirth, 1952a, 1952c).

Flight range, seasonal incidence, and other aspects of bionomics have been treated by Atchely and Hull, 1936; Bequaert, 1924; Carpenter, 1951; Downes, 1950; Foley and Picout-Laforest, 1923; Fox, 1952b; Fox and Maldonado, 1953; Gerry, 1953; Glick, 1939; Hull, *et al.*, 1934; Kettle, 1951a, 1951b, Meyers, 1932; Nicholas, 1953b, Parker, 1949; Roberts, 1950; Sergent, 1922; Shields and Hull, 1943; and Woke, 1954.

Control measures against the immature stages include the use of dikes and pumps (Anonymous, 1938, 1941; Dove and Hall, 1934; Hull and Dove, 1935; Hull, *et al.*, 1939, 1943; Platts, *et al.*, 1943) and treatment of the soil with insecticides such as DDT, BHC, dieldrin, and others (Anonymous,

1930; Dorsey, 1947; Curran and Goulding, 1950; Fennah, 1945; Gerry, 1950; Goulding, 1950; Goulding, *et al.*, 1953; Hill and Roberts, 1947; Kettle, 1949, 1952; Labrecque and Goulding, 1954; Labrecque, *et al.*, 1951; Madden, *et al.*, 1946; Rees and Smith, 1950, 1952; Steward, 1946; Wilson, 1951). Adults in houses are controlled by DDT and other sprays (Anonymous, 1947; Bishopp, 1946; Hull and Shields, 1939; Trapido, 1947) and temporary control out-of-doors is often obtained by DDT aerosols (Brescia and Wilson, 1947; Bruce and Blakeslee, 1948; Glascow and Collins, 1946; Travis, 1949; Wilson, *et al.*, 1949). Various repellents such as dimethyl pthalate and Indalone have been used with success (Applewhite and Cross, 1951; Applewhite and Smith, 1950; Cameron, 1946; Granett, *et al.*, 1949; Holden and Findlay, 1944; Peacock, *et al.*, 1948; Pijoan, *et al.*, 1946; Travis and Morton, 1950; Travis, *et al.*, 1946).

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KEY TO THE SUBGENERA OF *CULICOIDES* LATREILLE (MALES)

1. Ninth tergite rounded apically, the apicolateral processes absent or small and convergent 2
   Ninth tergite shaped variously, the apicolateral processes prominent and usually divergent 5
2. Aedeagus basally with a long curved hooklike process at the middle ..... *Macfiella*
   Aedeagus without such a process 3
3. Aedeagus triangular with a definite basal marginal band and extended tip; ventral root absent ..... *Hoffmania*
   Aedeagus otherwise, if triangular usually without a basal band; ventral root present 4
4. Ventral root long; inner side of basistyle without prominent setae ..... *Avaritia*
   Ventral root short; inner side of basistyle with prominent setae ..... *Culicoides*
5. Parameres fused medially to form a plate, sometimes with the tips free 6
   Parameres entirely separate 7
6. Plate (fused parameres) usually triangular with one apical point or two small lobes; aedeagus not bifid ..... *Selfia*

Plate with two apical points and aedeagus often bifid *Monoculicoides*

7. Parameres fringed with spines or long hairs apically on one side *Oecacta*
Parameres without such spines ..... *Beltranmyia*

KEY TO THE SUBGENERA OF *CULICOIDES* (FEMALES)

1. Wing with second radial cell in a light spot 2
Wing with second radial cell in a dark spot or without spots 4
2. Size small, 1.0 to 1.5 mm., wing markings faint and macrotrichiae scanty ..... *Avaritia*
Size large, 1.5 to 2.5 mm., wing markings distinct and macrotrichiae abundant 3
3. Wing with cubital fork in a light area ..... *Hoffmania*
Wing with cubital fork in a dark area ..... *Culicoides*
4. Spermathecae not apparent ..... *Selfia*
Spermathecae apparent, single or double 5
5. Spermatheca single, opening to the duct wide ..... *Monoculicoides*
Spermathecae usually double, if single the opening to the duct narrow 6
6. Fourth hind tarsal segment cordiform ..... *Macfiella*
Fourth hind tarsal segment cylindrical ..... *Oecacta, Beltranmyia*

MACFIELLA, NEW SUBGENUS

Male hypopygium with the ninth tergite more or less rounded apically, the apicolateral processes very small. Parameres separate the tips without spines. Aedeagus without a prominent arch, the apical portion long, distally truncate, basally with a long curved hooklike pointed process. Ventral root long with a prominent basal projection, dorsal root about as long as the ventral somewhat boot-shaped. Female with eyes contiguous, wing with second radial cell in a dark spot, spermathecae two, fourth tarsal segment of all the legs cordiform and wider than the fifth. Type, here designated, *Ceratopogon phlebotomus* Williston.

Only two species of this subgenus are known, *phlebotomus* (Williston) and *willistoni* Wirth and Blanton, and both are Neotropical. They are very similar as regards the hypopygium and wing but may be easily distinguished by the mesonotum, which in *willistoni* has a pattern of conspicuous dark spots, while in *phlebotomus* it is greenish gray without a distinct pattern.

SUBGENUS *HOFFMANIA* FOX

Hoffmania, Fox, 1947, 21. Ortiz, 1950, 437. Vargas, 1953a, 34. Type, by original designation, *Culicoides inamollae* Fox and Hoffman.

Male hypopygium with the ninth tergite rounded apically, the apicolateral processes small and convergent or absent. Parameres entirely separate or fused basally, the tips sometimes with fine hairs on both sides. Aedeagus more or less triangular with a basal marginal sclerotized band and distally extended to form a "peg". Ventral root absent, dorsal root more or less fingerlike. Females with the eyes contiguous; wing with the second radial cell mainly in a light spot and the cubital fork in a light area; spermathecae, two.

Only two species of this subgenus occur in the Nearctic Region, *venustus* Hoffman and *inamollae* Fox and Hoffman. The males may be distinguished by the parameres which in *venustus* are completely separated while in *inamollae* they are joined at their bases by a peculiar loop. The wing of the female of *venustus* usually has two small light spots in cell M_1 beyond the light spot on vein M_2 and the crossvein is in a light spot; the wing of the female of *inamollae* has only one light spot in the tip of cell M_1 and there is a dark spot on the cross vein at its junction with the first radial cell.

Neotropical species (including Mexico).—*bimaculatus* Floch and Abonnenc, *coutinhoi* Barretto, *decor* Williston, *diabolicus* Hoffman, *diminutus* Barbosa, *flavivenula* Lutz, *foxi* Ortiz, *guttatus* (Coquillett), *heliconiae* Fox and Hoffman, *hylas* Macfie, *inamollae* Fox and Hoffman, *insignis* Lutz, *lutzi* Lima, *maruim* Lutz, *ocumarensis* Ortiz, *oliveri* Fox and Hoffman, *recifei* Barbosa, *rozeboomi* Barbosa, *verecundus* Macfie.

AVARITIA, NEW SUBGENUS

Male hypopygium with the ninth tergite usually without a median notch and the apicolateral processes absent; in one species (*chiopterus*) with the posterior margin of the ninth tergite concave and the corners prominent but not forming characteristic processes. Parameres separate or joined basally, the tips with or without hairs. Aedeagus various, sometimes triangular. Inner margin of the basistyle without setae; ventral root very long, longer than the dorsal root. Females very small, 1.0–1.5 mm., eyes contiguous; wing markings faint, macrotrichiae scanty, the second radial cell usually in a light spot, but sometimes in a dark spot; spermathecae double. Type, here designated, *Ceratopogon obsoletus* Meigen.

Only two species of this subgenus occur in the Nearctic Region, *obsoletus* (Meigen) and *chiopterus* (Meigen). The females cannot be distinguished easily, but the males may be readily separated by the terminalia; in *chiopterus* the aedeagus is more or less triangular and the ninth sternite has a very wide excavation, but in *obsoletus* the aedeagus is different in shape and the ninth sternite has a narrow deep median notch. The Neotropical *pusillus* Lutz belongs to this subgenus on the basis of the terminalia, which resemble somewhat those of *chiopterus*, however, the female is unusual in that the second radial cell of the wing is in a dark spot.

SUBGENUS *CULICOIDES* LATREILLE

Culicoides Latreille, 1809, 251. Type, by original designation, *Culicoides pulicaris* (Linneaus) as *Culicoides punctata* Latreille. Vargas, 1953a, 33. Khalaf, 1954, 38.

Haemophructus Macfie, 1925, 349. Type, by monotypy, *Haemophructus maculipennis* Macfie.

Prosapelma Kieffer, 1925a, 417. Type, by original designation, *Prosapelma cinerea* Kieffer.

Male hypopygium with ninth tergite rounded, often projecting at the midline, apicolateral processes usually reduced or absent, sometimes long but weakly sclerotized. Aedeagus various, if triangular without a basal marginal band. Inner margin of the basistyle with prominent setae. Ventral root short, not longer than the dorsal root. Female large, 1.5 to 2.5 mm. long; eyes contiguous or very close together; wings with the second radial cell in a light spot and markings prominent, often with three broad transverse dark stripes, the middle one enclosing the basal portion of the cubital fork in a dark area; spermathecae double.

NEARCTIC FORMS.—*cockerellii cockerellii* (Coquillett), *c. saltonensis* Wirth, *luteovenus* Root and Hoffman, *sordidellus* (Zetterstedt), *tristriatulus* Hoffman, *yukonensis* Hoffman.

NEOTROPICAL SPECIES (INCLUDING MEXICO).—*beebei* Fox, *cova-garciai* Ortiz, *efferus* Fox, *elutus* Macfie, *luteovenus* Root and Hoffman, *yukonensis* Hoffman.

KEY TO THE NEARCTIC SPECIES OF *CULICOIDES* (MALES)

1. Apicolateral processes extending beyond the middle portion of the tergite 2
   Apicolateral processes not extending beyond the middle portion of the tergite 3
2. Basistyle with a pronounced hump on the inner margin ..... *yukonensis*
   Basistyle without such a hump ..... *tristriatulus*
3. Basal arms of aedeagus short, the distal triangular portion about twice their length ..... *luteovenus*
   Basal arms long, about as long as the distal portion ..... *c. cockerelli, c. saltonensis*

KEY TO THE NEARCTIC SPECIES OF *CULICOIDES* (FEMALES)

1. Wing with a dark spot centrally in cell Cu_1 ..... *yukonensis*
   Cell Cu_1 without such a dark spot 2
2. Mesonotum with three distinct dark bands ..... *tristriatulus*
   Mesonotum not as above 3

3. Hind tibiae with basal light bands ..... *luteovenus*
   Hind tibiae uniform brown or yellowish 4
4. Mesonotum usually uniform gray ..... *c. saltonensis*
   Mesonotum with two dark spots ..... *sordidellus, c. cockerellii*

SUBGENUS *SELFIA* KHALAF

Selfia Khalaf, 1954, 38. Type, by original designation, *Culicoides hieroglyphicus* Malloch.

Male hypopygium with ninth tergite of various shapes, apicolateral processes long and divergent. Parameres fused to form a plate usually triangular with one distal point but sometimes with two small lobes. Aedeagus consisting of two sclerotized pieces often fused apically. Ventral root prominent but often partly internal, dorsal root absent or internal. Females with spermathecae unsclerotized, not apparent; wings without spots.

NEARCTIC SPECIES.—*brookmani* Wirth, *denningi* Foote and Pratt, *hieroglyphicus* Malloch, *jamesi* Fox, *multipunctatus* Malloch, *tenuistylus* Wirth. No Neotropical species appear to have been described.

KEY TO THE NEARCTIC SPECIES OF *SELFIA* (MALES)

1. Plate (fused parameres) with a pair of lobes distally; aedeagus with three prongs apically ..... *multipunctatus*
   Plate without such lobes, more or less triangular; aedeagus not as above 2
2. Ninth sternite with projecting processes at least three times as long as wide ..... *hieroglyphicus*
   Ninth sternite without such processes 3
3. Aedeagus a pair of boomerang-shaped plates with apices widely separated ..... *brookmani*
   Aedeagus not as above 4
4. Dististyle distally foot-shaped ..... *jamesi*
   Dististyle distally slender 5
5. Apicolateral processes as long as or longer than the distances between their bases ..... *tenuistylus*
   Apicolateral processes much shorter than the distances between their bases ..... *denningi*

KEY TO THE NEARCTIC SPECIES OF *SELFIA* (FEMALES)

1. Mesonotum with small dark dots ..... *multipunctatus*
   Mesonotum otherwise 2
2. Mesonotum with broad light spots ..... *hieroglyphicus, denningi*
   Mesonotum uniform brown or with narrow light bands 3

3. Mesonotum uniform brown ..... *brookmani*
Mesonotum with two submedian light bands ..... *jamesi, tenuistylus*

SUBGENUS *MONOCULICOIDES* KHALAF

Monoculicoides Khalaf, 1954, 39. Type, by original designation, *Ceratopogon nubeculosus* Meigen.

Male hypopygium with ninth tergite shaped variously, the apicolateral processes broad and long. Parameres fused to form a plate usually bifid distally with two apical points. Aedeagus usually deeply bifid as well. Dorsal root usually longer than the ventral root and often boot-shaped. Females very large 2.0 mm. or more, with a small round tubercle above the base of each antenna; wings with the second radial cell in a dark spot; spermatheca single, large, often irregular in shape and with opening to the duct wide.

Only two species of this subgenus definitely occur in the Nearctic Region, *variipennis* (Coquillett) and *gigas* Root and Hoffman, which is known only from the female. The two species are easily distinguished by the mesonotum which in *variipennis* has a stippling of prominent brown dots while in *gigas* it is gray with indistinct markings; the spermathecae are also different being C-shaped in the former species and ovate in the latter. No Neotropical species appear to have been described, but *variipennis* occurs in Mexico.

SUBGENUS *OECACTA* POEY

Oecacta Poey, 1851, 236. Type, by monotypy, *Oecacta furens* Poey. Kieffer, 1906, 55. Kieffer, 1926, 106. Khalaf, 1954, 36 (in part).

Haematomyidium Goeldi, 1905, 137. Type, by original designation, *Haematomyidium paraense* Goeldi.

Psychophaena Philippi, 1865, 628. Type, by monotypy, *Culicoides venezuelensis* Ortiz and Mirsa as *Psychophaena pictipennis* Philippi (name preoccupied).

Diplosella Kieffer, 1921b, 113. Type, by monotypy, *Diplosella sergenti* Kieffer.

Male hypopygium with ninth tergite quadrangular, wider basally than apically, the apicolateral processes usually long, median cleft usually present. Parameres separate, the tips with spines varying in number and size forming a fringe on one side or with long hairs on one side, often with a lobelike swelling before the tip. Aedeagus with a wide basal arch. Ventral root in almost all the species with a basal projection giving the whole a "boathook" shape, dorsal root fingerlike about as long as the ventral root. Females usually with two spermathecae and wings usually with the second

radial cell included in a dark spot, occasionally wings uniform without dark spots.

NEARCTIC SPECIES.—*baueri* Hoffman, *floridensis* Beck, *furens* (Poey), *haematopotus* Malloch, *mohave* Wirth, *pifanoi* Ortiz; *piliferus* Root and Hoffman, *salihi* Khalaf, *stellifer* (Coquillett), *stilobezzioides* Foote and Pratt, *unicolor* (Coquillett).

NEOTROPICAL SPECIES (INCLUDING MEXICO).—*baueri* Hoffman, *bambusicola* Lutz, *carpenteri* Wirth and Blanton, *dampfi* Root and Hoffman, *dasyophrus* Macfie, *furens* (Poey), *galindoi* Wirth and Blanton, *gorgasi* Wirth and Blanton, *haematopotus* Malloch, *hoffmani* Fox, *iriartei* Fox, *lanei* Ortiz, *leopoldoi* Ortiz, *limai* Barretto, *lopesi* Barretto, *magnipalpis* Wirth and Blanton, *mojingaensis* Wirth and Blanton, *paraensis* (Goeldi), *pifanoi* Ortiz, *piliferus* Root and Hoffman, *propriipennis* Macfie, *scopus* Root and Hoffman, *stigmalis* Wirth, *uniradialis* Wirth and Blanton, *venezuelensis* Ortiz and Mirsa.

KEY TO THE NEARCTIC SPECIES OF *OECACTA* (MALES)

1. Apex of aedeagus bent anteriorly; parameres with several long hairs before the tip ..... *stilobezzioides*
   Aedeagus not as above; parameres with spines apically 2
2. Arch of aedeagus with a distinct process on each side 3
   Arch of aedeagus without such processes 5
3. Parameres with a lobelike swelling before the broadly expanded tip *haematopotus*
   Parameres without lobelike swellings and the tips not broadly expanded 4
4. Processes on arch of aedeagus very long, longer than one-half the apical portion of the aedeagus ..... *salihi*
   Processes on arch of aedeagus shorter than one-half the apical portion *baueri*
5. Apex of aedeagus clearly divided into lobes 6
   Apex of aedeagus not divided, but may be striated 7
6. Apicolateral processes longer than the distance between them *furens*
   Apicolateral processes shorter than the distance between them *pifanoi*
7. Parameres with a lobelike swelling on stem before the tip 8
   Parameres slender without lobelike swellings 9
8. Fringing spines of parameres limited to an expanded basal portion of tip ..... *stellifer*
   Fringing spines not so limited and tip not expanded ..... *mohave*

9. Apex of aedeagus truncate and striated; basal projection of ventral root distinct ..... *piliferus*
Apex of aedeagus pointed or conelike; basal projection of ventral root indefinite 10
10. Apicolateral processes long and prominent ..... *unicolor*
Apicolateral processes very short ..... *floridensis*

SUBGENUS *BELTRANMYIA* VARGAS

Beltranmyia Vargas, 1953a, 34. Type, by original designation, *Culicoides crepuscularis* Malloch.

Male hypopygium as in *Oecacta* except that the parameres do not have a fringe of spines on one side at the tip. The ventral root is usually long and slender but may be short or even absent and rarely in the shape of a "boathook". Females usually with two spermathacae but often with one, otherwise as in *Oecacta*.

NEARCTIC FORMS.—*alaskensis* Wirth, *arboricola* Root and Hoffman, *biguttatus* (Coquillett), *canithorax* Hoffman, *copiosus* Root and Hoffman, *crepuscularis* Malloch, *guttipennis* (Coquillett), *hinmani* Khalaf, *horneae* Foote and Pratt, *loughnani* Edwards, *melleus* (Coquillett), *monoensis* Wirth, *nanus* Root and Hoffman, *niger* Root and Hoffman, *ousairani* Khalaf, *palmerae* James, *pumilus* (Winnertz), *spinosus* Root and Hoffman, *stonei* James, *travisi* Vargas, *usingeri* Wirth, *utahensis* Fox, *villosipennis villosipennis* Root and Hoffman, *v. oklahomensis* Khalaf, *weesei* Khalaf, *wirthi* Foote and Pratt.

NEOTROPICAL SPECIES (INCLUDING MEXICO).—*albomacula* Root and Hoffman, *arubae* Fox and Hoffman, *aureus* Ortiz, *bahiensis* Barbosa, *borinqueni* Fox and Hoffman, *briceñoi* Ortiz, *copiosus* Root and Hoffman, *crepuscularis* Malloch, *daedalus* Macfie, *dominicii* Ortiz, *eublepharus* Macfie, *fluvialis* Macfie, *guyanensis* Floch and Abonnenc, *hertigi* Wirth and Blanton, *jamaicensis* Edwards, *kintzi* Wirth and Blanton, *loughnani* Edwards, *macrostigma* Wirth and Blanton, *panamensis* Barbosa, *propinquus* Macfie, *reticulatus* Lutz, *stigmalis* Wirth, *trilineatus* Fox, *wirthomyia* Vargas.

KEY TO THE NEARCTIC SPECIES OF *BELTRANMYIA* (MALES)

1. Ventral root greatly reduced or absent 2
Ventral root various not greatly reduced or absent 3
2. Apex of aedeagus pointed ..... *alaskensis, crepuscularis*
Apex of aedeagus truncate ..... *canithorax*
3. Aedeagus consisting of the arch only ..... *pumilus*
Apex of aedeagus expanded and otherwise modified 4

4. Parameres with apex flaring into several radiating points 5
   Parameres not so modified 6
5. Apex of aedeagus narrow, not much wider than an apicolateral process *spinosus*
   Apex of aedeagus broadly rounded, much wider than an apicolateral process ..... *usingeri*
6. Apex of aedeagus with a conspicuous hooklike process on each side distally ..... *melleus*
   Aedeagus without such processes 7
7. Apex of aedeagus with lateral lobes or with a mesal notch 8
   Aedeagus not as above 9
8. Apex of aedeagus with 1 or 2 distinct lobes on each side *v. villosipennis, v. oklahomensis*
   Apex of aedeagus with a mesal notch and lateral points .... *monoensis*
9. Aedeagus deeply excavated at distal third to form distinct shoulders and a narrow apex ..... *palmerae*
   Aedeagus not as above 10
10. Membrane spiculate 11
    Membrane bare 14
11. Dististyles markedly bent beyond the middle; apex of aedeagus pointed; ventral root short, broad, and mostly internal ..... *guttipennis*
    Dististyles not markedly bent; apex of aedeagus truncate; ventral root slender and external 12
12. Ventral roots very long, longer than the dorsal roots and almost meeting ..... *biguttatus*
    Ventral roots shorter, about as long as the dorsal roots 13
13. Dististyle short, about one-half as long as basistyle and distally expanded ..... *copiosus*
    Dististyle long, about as long as basistyle and distally attenuated *weesei*
14. Apex of aedeagus extended to a very slender point *arboricola, ousairani*
    Apex of aedeagus rounded or truncate 15
15. Parameres enlarged in middle as wide as or wider than at the base .. 16
    Parameres slender, tapering to tip, much wider at base than in the middle 18
16. Base of parameres bent almost at right angles; ninth tergite without a median notch ..... *loughnani*
    Parameres not as above; ninth tergite with a notch 17
17. Dististyle bent at base; ventral root obscure, shorter than dorsal root *utahensis*
    Dististyle not as above; ventral root as long as or longer than dorsal root ..... *niger, hinmani*

18. Apicolateral processes very wide at base, each wider than distance between them; ventral root about one-half as long as dorsal root *stonei*

Apicolateral processes narrower than the distance between them; ventral root about as long or longer than dorsal root 19

19. Apical portion of aedeagus much extended giving the whole the shape of an inverted Y. ..... *travisi, horneae*

Apical portion of aedeagus not greatly extended, triangular, massive, giving the whole the shape of an inverted V..... 20

20. Paramere greatly enlarged and footlike at the base..... *wirthi*

Paramere not as above..... *nanus*

Nocivum Harris, briefly described in 1862, has never been identified and so is omitted from the following key to the females of *Beltranmyia* and *Oecacta*. Also omitted are three species of Foote and Pratt which are known only from the males, *horneae*, *stilobezzioides* and *wirthi*. *Reevesi* Wirth was described only from the female, hence its subgenus cannot be definitely determined, however, it probably belongs in one of these subgenera and is included in the key. There are a number of Neotropical species whose males are undescribed which also appear to belong in these two subgenera, as follows: *acotylus* Lutz, *alahialinus* Barbosa, *alambiculorum* Macfie, *avilaensis* Ortiz and Mirsa, *bennarrochei* Ortiz and Mirsa, *cacozelus* Macfie, *caprilesi* Fox, *caridei* Brèthes, *castillae* Fox, *debilipalpis debilipalpis* Lutz, *d. equatoriensis* Barbosa, *d. glabrior* Macfie, *discrepans* Ortiz and Mirsa, *flochabonnenci* Ortiz, and Mirsa, *germanus* Macfie, *gibsoni* Wirth, *ginesi* Ortiz, *guadeloupensis* Floch and Abonnenc, *horticola* Lutz, *leoni* Barbosa, *lichyi* Floch and Abonnenc, *obnoxius* Fox, *pachymerus* Lutz, *pampoikilus* Macfie, *paucienfuscatus* Barbosa, *poikilonotus* Macfie, *pulchripennis* Macfie, *rangeli* Ortiz and Mirsa, *wokei* Fox.

KEY TO THE NEARCTIC SPECIES OF *BELTRANMYIA* AND *OECACTA* (FEMALES)

1. Spermatheca single..... 2

Spermathecae double..... 4

2. Ring present; antennal flagellum with segments in a continuous series, segment XI not much larger than X..... *reevesi*

Ring absent; an abrupt change in shape between antennal segments X and XI, the latter much larger than the former..... 3

3. Apical half of second radial cell in a light spot; third palpal segment moderate in size; mesonotum without a distinct pattern *canithorax*

Apical half of second radial cell in a dark spot; third palpal segment large and swollen; mesonotum with a distinct pattern *crepuscularis, alaskensis*

4. Wing uniform without light or dark spots 5
   Wing with light or dark spots 8
5. Spermathecae large, dark, without ring 6
   Spermathecae smaller, light, with ring 7
6. Third palpal segment with pit small or indefinite ..... *melleus*
   Third palpal segment with a large pit ..... *stonei, weesei*
7. Legs uniform brownish black; mesonotum shining black ..... *monoensis*
   Legs light yellow, sometimes with knees dark; mesonotum yellow or brown ..... *salihi, floridensis, pumilus*
8. Wing with only two distinct light spots, one on the cross vein and one just beyond the second radial cell 9
   Wing with other light spots as well as those on the cross vein and beyond the second radial cell 10
9. Hind tibial comb with 5 or 6 spines ..... *unicolor*
   Hind tibial comb with 4 spines ..... *usingeri, spinosus, biguttatus*
10. Basal half of cell M_1 with a light area or with a light spot on vein M_2 11
    Basal half of cell M_1 dark ..... *travisi, nanus, hollensis*
11. No light spots in the apical halves of cells R_5 and M_1 and a transverse row of light spots across the middle of the wing ..... *niger*
    Wing not as above 12
12. Hind tibial comb with 5 or 6 spines 13
    Hind tibial comb with 4 spines 17
13. Wing with circumscribed light spots straddling veins M_1 and M_2 14
    Wing without such light spots 16
14. Light spot on cross vein small hardly extending beyond vein M_1 ..... *villosipennis*
    Light spot on cross vein large extending well beyond vein M_1 15
15. Vein Cu_2 with a light border ..... *arboricola, ousairani*
    Vein Cu_2 without a light border ..... *guttipennis, v. oklahomensis*
16. Cell R_5 with 3 light spots, the distal 2 may be connected to form a single inverted U-shaped spot; cell M_1 with 3 light spots ..... *stellifer*
    Cells R_5 and M_1 with at most 2 light spots ..... *unicolor*
17. Cell R_5 with at least 2 light spots in addition to the one just beyond the second radial cell; mesonotal pattern consisting of many small dark dots ..... *furens*
    Cell R_5 with 1 light spot only in addition to the one just beyond the second radial cell; mesonotum not as above 18
18. Distal light spot of cell R_5 small, near the tip of the wing ..... *haematopotus*
    Cell R_5 not as above 19

19. Third palpal segment large and swollen, about 1½ times as long as the first and second together 20
Third palpal segment moderate, only slightly longer than the first and second 22
20. Cubital fork in a light area, cell R_5 with a dark spot at the middle and at the tip ..... *loughnani*
Cubital fork in a dark area, cell R_5 not as above 21
21. Cell R_5 clearly with a double light spot at the middle; mesonotum with a distinct pattern ..... *baueri*
Cell R_5 with a faint oval spot at the middle; mesonotum without a pattern ..... *copiosus*
22. Last 5 segments of antennal flagellum much shorter than first 8 ..... *pifanoi*
Last 5 segments about equal to or longer than the first 8 23
23. Size very small, about 1.0 mm. 24
Size larger, about 1.3 mm. 25
24. Base of vein M_2 straddled by a light spot; mesonotum with a distinct pattern ..... *hinmani*
Base of vein M_2 without a spot; mesonotum without a pattern ..... *mohave*
25. A light spot in the middle of vein M_2 ..... *piliferus*
A light area at the base of vein M_2 ..... *utahensis, palmerae*

CULICOIDES LATREILLE

acotylus Lutz

Culicoides acotylus Lutz, 1913, 69 (♀, Salto Augusto, Rio Tapajoz, Brazil). Vargas, 1945, 43. Barbosa, 1947, 10 (♀, Brazil). Macfie, 1948, 74. Ortiz and Peña Garcia, 1948, 6 (Venezuela). Vargas, 1949b, 194. Iriarte, 1950, 391. Ortiz, 1951a, 8 (Venezuela). Ortiz and Mirsa, 1952b, 258 (♀, Venezuela).
Culicoides acolytus Lima, 1937, 413.
Culicoides panamericanus Fox, 1947, 90 (♀, Mexico).

alahialinus Barbosa

Culicoides alahialinus Barbosa, 1952, 11 (♀, Limones, Esmeralda, Ecuador).

alambiculorum Macfie

Culicoides alambiculorum Macfie, 1948, 81 (♀, El Vergel, Chiapas, Mexico).

alaskensis Wirth

Culicoides alaskensis Wirth, 1951a, 84 (♂♀, Valdez, Alaska). Williams, 1951a, 181 (Alaska).
Culicoides (*Monoculicoides*) *alaskensis* Khalaf, 1954, 40.

albomacula Root and Hoffman

Culicoides albomacula Root and Hoffman, 1937, 164 (♂ ♀, San Jacinto, D. F., Mexico). Vargas, 1945, 44 (Mexico). Macfie, 1948, 71. Vargas, 1949b, 194. Ortiz, 1950, 462.
Culicoides albomaculatus Johannsen, 1943, 779.
Culicoides (*Oecacta*) *albomacula* Khalaf, 1954, 36.

amazonius Macfie

See *Culicoides phlebotomus* (Williston).

ancorus Coquillett

Ceratopogon ancorus Coquillett, 1902, 87.
Culicoides ancorus Kieffer, 1906, 54.
REMARKS.—A species of *Dasyhelea* (Wirth, 1952a, 159).

arboricola Root and Hoffman

Culicoides arboricola Root and Hoffman, 1937, 166 (♂ ♀, Baltimore, Md.; Georgia, Mississippi, U. S. A.) Fox, 1942, 416 (pupa, Maryland, U. S. A.) Johannsen, 1943, 779. Vargas, 1945, 43. Vargas, 1949b, 194. Ortiz, 1950, 462. Johannsen, 1952, 161. Khalaf, 1952b, 349 (Oklahoma, U. S. A.) Beck, 1952, 103 (Florida, U. S. A.). Snow and Pickard, 1953, 28 (Tennessee, U. S. A.) Foote and Pratt, 1954, 15 (♂ ♀, Florida, Georgia, Illinois, Louisiana, U. S. A.).
Culicoides (*Oecacta*) *arboricola* Khalaf, 1954, 37.

arubae Fox and Hoffman

Culicoides arubae Fox and Hoffman, 1944, 109 (♂ ♀, Aruba, D. W. I.). Vargas, 1945, 43. Fox, 1946a, 250. Anduze, *et al.*, 1947, 11 (Venezuela). Barbosa, 1947, 11 (♂ ♀, Venezuela; Canal Zone). Macfie, 1948, 71. Ortiz and Peña Garcia 1948, 7 (Venezuela). Ortiz, 1949, 326 (Venezuela). Floch and Abonnenc, 1949a, 71. Vargas, 1949b, 195. Iriarte, 1950, 369. Ortiz, 1950, 462. Ortiz, 1951a, 10. Ortiz and Mirsa, 1952b, 269 (♂ ♀, Venezuela)
Culicoides species (1) Fox, 1942, 420 (pupa, D. W. I.).
Culicoides variipennis Ortiz (not Coquillett), 1942, 258 (Venezuela). Iriarte, 1943, 192 (Venezuela).

aureus Ortiz

Culicoides aureus Ortiz, 1951c, 585 (♀, San Felipe, Yaracuy, Venezuela).
Culicoides miyamotoi Wirth and Blanton, 1953b, 231 (♂ ♀, Canal Zone).
REMARKS.—The above synonymy is given on the authority of Wirth (personal communication).

avilaensis Ortiz and Mirsa

Culicoides avilaensis Ortiz and Mirsa, 1951, 593 (♀, Los Chorros, Miranda, Venezuela).

bahiensis Barbosa

Culicoides bahiensis Barbosa, 1947, 11 (♂♀, Bahia, Brazil). Vargas, 1949b, 195. Ortiz, 1950, 462.

bambusicola Lutz

Culicoides bambusicola Lutz, 1913, 62 (♂, Brazil). Rieth, 1915, 417. Lima, 1937, 412. Barretto, 1944, 95 (♂, Brazil). Vargas, 1945, 43. Lane, 1947, 166 (larva, pupa, Brazil). Macfie, 1948, 71. Vargas, 1949b, 195.

Culicoides bambusicolus Barbosa, 1947, 12 (Brazil). Ortiz, 1950, 462. Barbosa, 1952, 11 (larva, pupa).

Culicoides (*Oecacta*) *bambusicola* Khalaf, 1954, 37.

baueri Hoffman

Culicoides baueri Hoffman, 1925, 297 (♀, Baltimore, Md., U. S. A.). Root and Hoffman, 1937, 163 (♂♀, Mexico). Johannsen, 1943, 779. James, 1943, 149 (Colorado, U. S. A.) Vargas, 1945, 44 (Mexico). Macfie, 1948, 72. Vargas, 1949b, 195. Ortiz and Mirsa, 1951, 559 (♂♀, Venezuela) Wirth, 1952a, 183 (♂♀, California, U. S. A.) Johannsen, 1952, 160. Beck, 1952, 104 (Florida, U. S. A.). Snow and Pickard, 1953, 28 (Tennessee, U. S. A.). Foote and Pratt, 1954, 16 (♂♀, Georgia, California, Maryland, U. S. A.).

Culicoides bahueri Ortiz, 1950, 462. Ortiz, 1951a, 9. Ortiz, 1951b, 442 (Venezuela).

Culicoides (*Oecacta*) *baueri* Khalaf, 1954, 37.

beebei Fox

Culicoides beebei Fox, 1952a, 366 (♀, Rancho Grande near Maracay, Venezuela).

bellus Coquillett

Ceratopogon bellus Coquillett, 1902, 87.

Culicoides bellus Kieffer, 1906, 54.

REMARKS.—A species of *Alluaudomyia* (Wirth, 1952a, 195).

benarrochei Ortiz and Mirsa

Culicoides benarrochei Ortiz and Mirsa, 1952a, 127 (♀, Caraballeda, Vargas, Dpto. Federal, Venezuela).

biguttatus Coquillett

Ceratopogon biguttatus Coquillett, 1901, 604 (♀, Washington, D. C., U. S. A.). Aldrich, 1905, 108.

Culicoides biguttatus Kieffer, 1906, 54. Malloch, 1915b, 308 (♀, Illinois, U. S. A.). Hoffman, 1925, 283 (♀, Maryland, Massachusetts, New York, Texas, U. S. A.) Leonard, 1928, 707 (New York, U. S. A.). Metcalf, 1932, 5 (New York, U. S. A.). Metcalf and Sanderson, 1932, 59 (New York, U. S. A.). Jellison and Phillips, 1933, 26 (Montana, U. S. A.). Root and Hoffman, 1937, 170 (♂ ♀, Connecticut, U. S. A.). Thomsen, 1937, 70 (pupa, New York, U. S. A.). Curtis, 1941, 18 (Canada). Johannsen, 1943, 779. Vargas, 1945, 43. Vargas, 1949b, 195. Ortiz, 1950, 462. Wirth, 1951c, 318 (Virginia, U. S. A.). Johannsen, 1952, 160. Beck, 1952, 103 (Florida, U. S. A.). Snow and Pickard, 1953, 28 (Tennessee, U. S. A.). Foote and Pratt, 1954, 16 (♂ ♀, Florida, Georgia, Illinois, Kansas, Maryland, Massachusetts, New Jersey, New York, Ohio, Pennsylvania, Texas, Vermont, Virginia, U. S. A.).

Culicoides (*Oecacta*) *biguttatus* Khalaf, 1954, 38.

bimaculatus Floch and Abonnenc

Culicoides bimaculatus Floch and Abonnenc, 1942b, 3 (♀, Cayenne, French Guiana). Barbosa, 1947, 8. Vargas, 1949b, 195. Floch, 1952, 295 (French Guiana).

borinqueni Fox and Hoffman

Culicoides borinqueni Fox and Hoffman, 1944, 110 (♂ ♀, Palmas Abajo, P. R.). Vargas, 1945, 43. Barbosa, 1947, 12. Wolcott, 1948, 426. Fox 1949, 30 (♂ ♀, Puerto Rico). Vargas, 1949b, 195. Fox and Kohler, 1950, 342 (Puerto Rico). Ortiz, 1950, 462. Fox and Maldonado, 1953, 165, (Puerto Rico).

Culicoides species (2) Fox, 1942, 417 (pupa, Puerto Rico).

briceñoi Ortiz

Culicoides briceñoi Ortiz, 1951a, 10 (Venezuela). Ortiz, 1951b, 445 (♂, Venezuela).

brookmani Wirth

Culicoides brookmani Wirth, 1952a, 179 (♂ ♀, Arroyo Seco Ranger Station, Monterey Co., Cal., U. S. A.).

Culicoides (*Selfia*) *brookmani* Khalaf, 1954, 38.

cacozelus Macfie

Culicoides cacozelus Macfie, 1948, 85 (♀, El Vergel, Chiapas, Mexico) Ortiz, 1951c, 581 (♀, Venezuela).

Culicoides cacozeleus Vargas, 1949b, 195.

canithorax Hoffman

Culicoides canithorax Hoffman, 1925, 284 (♀, Brunswick, Ga., U. S. A.). Dove, *et al.*, 1932, 508 (South Carolina, U. S. A.). Atchley and Hull, 1936, 514. Root and Hoffman, 1937, 160 (♂ ♀, Maryland, South Carolina, U. S. A.). Johannsen, 1943, 779. Vargas, 1945, 43. Vargas, 1949b, 195. Dove, 1949, 869. Ortiz, 1950, 462. Johannsen, 1952, 160. Beck, 1952, 103 (Florida, U. S. A.). Foote and Pratt, 1954, 17 (♂ ♀, Delaware, Florida, Georgia, Maine, Maryland, Massachusetts, Mississippi, New Jersey, South Carolina, U. S. A.).

Culicoides mississippiensis Hoffman, 1926a, 158 (♀, Mississippi, U. S. A.). Hinman, 1932, 773 (Louisiana, Mississippi, U. S. A.). Root and Hoffman, 1937, 160 (♀, Louisiana, U. S. A.). Johannsen, 1943, 779. Vargas, 1945, 43. Vargas, 1949b, 195. Foote and Pratt, 1954, 17. Bradley, 1954, 126.

Culicoides (*Beltranmyia*) *canithorax* Vargas, 1953a, 35.

Culicoides (*Monoculicoides*) *canithorax* Khalaf, 1954, 40.

caprilesi Fox

Culicoides caprilesi Fox, 1952a, 364 (♀, Mount Marahuaca, Venezuela).

caridei Brèthes

Cotocripus caridei Brèthes, 1912, 451 (♀, Buenos Aires, Argentina). Lutz, 1914, 81.

Centrorhynchus setifer Lutz, 1913, 64 (♀, Brazil).

Culicoides setifer Edwards, 1922, 166. Vargas, 1945, 43.

Culicoides caridei Lane 1945, 366 (♀, Brazil; Argentina). Barbosa, 1947, 13 (Uruguay). Macfie, 1948, 69. Vargas, 1949b, 195.

Dasyhelea caridei Lane and Ortiz, 1950, 460.

castillae Fox

Culicoides castillae Fox, 1946a, 251 (♀, Puerto Castilla, Honduras). Barbosa, 1947, 7. Macfie, 1948, 73. Vargas, 1949b, 196. Ortiz, 1950, 462. Ortiz and Mirsa, 1952a, 126.

carpenteri Wirth and Blanton

Culicoides carpenteri Wirth and Blanton, 1953a, 72 (♂ ♀, Madden Dam, C. Z.).

chiopterus Meigen

Ceratopogon chiopterus Meigen, 1830, 263 (Europe).

Ceratolphus chiopterus Kieffer, 1906, 60 (North America).

Culicoides chiopterus Root and Hoffman, 1937, 156 (♂, Maryland, U. S. A.). Johannsen, 1943, 779. Vargas, 1945, 43. Vargas, 1949b, 196. Ortiz, 1950, 462. Johannsen, 1952, 160. Kettle and Lawson, 1952, 447 (larva, pupa,

England). Downes and Kettle, 1952, 66 (♂ ♀, Scotland). Foote and Pratt, 1954, 18, ♂.

Culicoides (*Culicoides*) *chiopterus* Khalaf, 1954, 39.

REMARKS.—This species is widely distributed in Europe (Kieffer, 1925b, 76; Goetghebuer and Lenz, 1934, 41; Edwards, 1939, 143; Hill, 1947, 107).

cinctus Coquillett

Ceratopogon cinctus Coquillett, 1901, 605.

Culicoides cinctus Kieffer, 1906, 54.

REMARKS.—A species of *Dasyhelea* (Wirth, 1952a, 150).

cockerellii Coquillett

Ceratopogon cockerellii Coquillett, 1901, 603 (♀, Custer Co., Colo., U. S. A.).

Ceratopogon cockerelli Aldrich, 1905, 108.

Culicoides cockerelli Kieffer, 1906, 54. Hoffman, 1925, 293 (♀, Colorado, U. S. A.; Canada). Root and Hoffman, 1937, 157 (Canada). Curtis, 1941, 18 (Canada). Johannsen, 1943, 779. James, 1943, 149 (♂, Colorado, U. S. A.). Vargas, 1945, 43. Vargas, 1949b, 196.

Culicoides cockerellii Knowlton and Fronk, 1950, 114 (Utah, U. S. A.). Wirth, 1951a, 81 (♂ ♀, Alaska). Wirth, 1952a, 171 (♂ ♀, California, Colorado, Utah, Wyoming, U. S. A.; Alaska; Canada). Foote and Pratt, 1954, 18 (♂ ♀, Montana, Wyoming, U. S. A.).

Culicoides (*Culicoides*) *cockerellii* Khalaf, 1954, 39.

cockerellii saltonensis Wirth

Culicoides cockerellii saltonensis Wirth, 1952a, 173 (♂ ♀, Seeley, Imperial Co., Calif., U. S. A.).

Culicoides (*Culicoides*) *c. saltonensis* Khalaf, 1954, 39.

cockerelli var. tristriatulus Hoffman

See *Culicoides tristriatulus* Hoffman

columbianus Kieffer

Culicoides columbianus Kieffer, 1917b, 304.

Dasyhelea columbianus Kieffer, 1919a, 64.

REMARKS.—Macfie, 1948, 69, states that this is not a *Culicoides*.

copiosus Root and Hoffman

Culicoides copiosus Root and Hoffman, 1937, 171 (♂ ♀, San Jacinto, D.F., Mexico). Johannsen, 1943, 779. Vargas, 1945, 49 (♂, Mexico). Macfie,

1948, 69. Vargas, 1949b, 196. Ortiz, 1950, 462. Wirth, 1952a, 191 (♂ ♀, California, U. S. A.).
Culicoides (*Occacta*) *copiosus* Khalaf, 1954, 37.

coutinhoi Barretto

Culicoides coutinhoi Barretto, 1944, 96 (♂, Mogi das Cruzes e Prainha, S. Paulo, Brazil). Barbosa, 1947, 13 (♀, Brazil). Vargas, 1949b, 196. Ortiz, 1950, 449.
Culicoides (*Culicoides*) *coutinhoi* Khalaf, 1954, 46.

cova-garciai Ortiz

Culicoides cova-garciai Ortiz, 1950, 457 (♂ ♀, Caracas, Venezuela). Ortiz, 1951a, 9. Ortiz, 1951b, 444.
Culicoides (*Culicoides*) *cova-garciai* Khalaf, 1954, 39.

crepuscularis Malloch

Culicoides crepuscularis Malloch, 1915a, 303 (♂ ♀, Dubois, Ill., Arizona, Michigan, U. S. A.). Hoffman, 1925, 298 (♀, Colorado, Maryland, New Mexico, Texas, U. S. A.). Jellison and Philip, 1933, 26 (Montana, U. S. A.). Root and Hoffman, 1937, 159 (♂ ♀, Montana, U. S. A.; Mexico). Thomsen, 1937, 70 (pupa, New York, U. S. A.). Adams, 1940, 125 (Missouri, U. S. A.). Curtis, 1941, 18 (Canada). Fox, 1942, 415 (pupa, Maryland, U. S. A.). Johannsen, 1943, 779. James, 1943, 149 (Colorado, U. S. A.). Vargas, 1945, 44 (Mexico). Macfie, 1948, 71. Vargas, 1949b, 196. Knowlton and Fronk, 1950, 113 (Utah, U. S. A.). Ortiz, 1950, 462. Gerry, 1950, 191 (Massachusetts, U. S. A.). Knowlton and Kardos, 1951, 163 (Utah, U. S. A.). Wirth, 1951c, 318 (Virginia, U. S. A.). Wirth, 1952a, 188 (♂ ♀, California, Colorado, Florida, Georgia, Kansas., Maryland, Minnesota, Montana, Nebraska, South Dakota, Texas, Utah, Virginia, Washington, Wyoming, U. S. A.; Canada). Johannsen, 1952, 160. Khalaf, 1952b, 349 (Oklahoma, U. S. A.). Beck, 1952, 103 (Florida, U. S. A.). Snow and Pickard, 1953, 28 (Tennessee, U. S. A.). Foote and Pratt, 1954, 19 (♂ ♀, Alabama, Florida, Georgia, Illinois, Kansas, Maryland, Michigan, Montana, New Jersey, New York, South Dakota, Virginia, Utah, Vermont, U. S. A.). Edmunds and Keener, Jr., 1954, 82 (Nebraska, U. S. A.).
Culicoides (*Beltranomyia*) *crepuscularis* Vargas, 1953a, 35.
Culicoides (*Monoculicoides*) *crepuscularis* Khalaf, 1954, 40.

daedalus Macfie

Culicoides daedalus Macfie, 1948, 83 (♂, El Vergel, Chiapas, Mexico). Vargas, 1949b, 196. Ortiz, 1950, 462. Ortiz and Mirsa, 1952b, 277 (♂ Venezuela).

Culicoides sp. Ortiz, 1951c, 583 (♀, Venezuela).
Culicoides (*Oecacta*) *daedalus* Khalaf, 1954, 37.

dampfi Root and Hoffman

Culicoides dampfi Root and Hoffman, 1937, 169 (♂♀, San Jacinto, D. F., Mexico). Johannsen, 1943, 779. Vargas, 1945, 44 (Mexico). Macfie, 1948, 71. Vargas, 1949b, 197. Ortiz, 1950, 462.
Culicoides (*Oecacta*) *dampfi* Khalaf, 1954, 36.

dasyophrus Macfie

Culicoides dasyophrus Macfie, 1940a, 27 (♂♀, New River, British Guiana). Vargas, 1945, 43. Macfie, 1948, 74. Vargas, 1949b, 197. Ortiz, 1950, 462. Carpenter, 1951, 205 (Canal Zone). Ortiz and Mirsa, 1952a, 126 (♀, Venezuela).
Culicoides dasyophorus Barbosa, 1947, 13 (♂, Canal Zone).

debilipalpis Lutz

Culicoides debilipalpis Lutz, 1913, 60 (♀, Anhemby, São Paulo, Brazil). Macfie, 1937, 7 (♀, Trinidad). Lima, 1937, 420 (♀, Brazil). Macfie, 1938, 164 (Trinidad). Macfie, 1939, 200 (♀, Brazil). Adamson, 1939, 79 (Trinidad). Floch and Abonnenc, 1942a, 9 (♀, French Guiana). Vargas, 1945, 43. Briceño-Iragorry, 1946, 398 (Venezuela). Anduze *et al.*, 1947, 11 (Venezuela). Barbosa, 1947, 14 (♀, Brazil; Barbados; St. Croix; Trinidad; Venezuela). Macfie, 1948, 86 (♀, Mexico). Briceño-Iragorry, 1949, 318 (Venezuela). Floch and Abonnenc, 1949a, 71 (Venezuela). Vargas, 1949b, 197. Iriarte, 1950, 388. Ortiz, 1951a, 10 (Venezuela). Barbosa, 1952, 12 (pupa, Argentina; Brazil).

debilipalpis equatoriensis Barbosa

Culicoides debilipalpis equatoriensis Barbosa, 1952, 13 (♀, Sto. Domingo, Colorados, Ecuador).

debilipalpis glabrior Macfie

Culicoides debilipalpis var. *glabrior* Macfie, 1940a, 27 (♀, New River, British Guiana). Vargas, 1945, 43. Barbosa, 1947, 14 (Panama). Macfie, 1948, 73. Vargas, 1949b, 197. Warmke, 1952, 474 (Brazil).

decor Williston

Ceratopogon decor Williston, 1896, 281 (♀, St. Vincent). Aldrich, 1905, 108. Kieffer, 1906, 50.
Culicoides decor Johannsen, 1943, 779. Vargas, 1945, 43. Macfie, 1948, 68. Vargas, 1949b, 197.

Culicoides (*Hoffmania*) *decor* Ortiz, 1950, 439.
Culicoides (*Culicoides*) *decor* Khalaf, 1954, 46.

denningi Foote and Pratt

Culicoides denningi Foote and Pratt, 1954, 20 (♂ ♀, Saskatoon, Saskatchewan, Canada; Wyoming, U. S. A.).

diabolicus Hoffman

Culicoides diabolicus Hoffman, 1925, 294 (♀, Cabima, Panama). Macfie, 1932, 487 (♀, Colombia). Lima, 1937, 417 (♀, Brazil). Adamson, 1939, 81 (Trinidad). Kumm, *et al.*, 1940, 420 (Costa Rica). Floch and Abonnenc, 1942a, 2 (French Guiana). Fairchild, 1943, 572 (Panama). Johannsen, 1943, 779. Vargas, 1944, 163 (♂ ♀, Mexico). Vargas, 1945, 43. Floch, 1952, 295 (French Guiana). Macfie, 1953, 102 (Costa Rica).
Culicoides species Dampf, 1936a, 228 (♀, Mexico).
Culicoides guttatus var. *diabolicus* Macfie, 1937, 8 (♂ ♀, Trinidad).
Culicoides filariferus Hoffman, 1939, 172 (♀, Mexico). Gibson and Ascoli, 1952, 315. Bradley, 1954, 135. Foote and Pratt, 1954, 1.
Culicoides guttatus (*diabolicus*) Macfie, 1940a, 25 (British Guiana). Woke, 1954, 69 (Panama).
Culicoides pseudodiabolicus Fox, 1946a, 256 (♀, Trinidad). Vargas, 1949b, 204.
Culicoides guttatus Macfie, 1948, 74.
Culicoides (*Hoffmania*) *diabolicus* Fox, 1948, 24 (♂ ♀, Canal Zone). Ortiz, 1950, 446.
Culicoides (*Culicoides*) *diabolicus* Khalaf, 1954, 46.

diminutus Barbosa

Culicoides diminutus Barbosa, 1951, 163 (new name for *wokei* Barbosa, preoccupied). Woke, 1954, 68 (Canal Zone; Nicaragua).
Culicoides wokei Barbosa (not Fox), 1947, 28 (♂ ♀, Balboa, C. Z.; Mexico; Guatemala; Nicaragua). Vargas, 1949b, 208. Ortiz, 1950, 464.

discrepans Ortiz and Mirsa

Culicoides discrepans Ortiz and Mirsa, 1951, 595 (♀, Los Chorros, Miranda, Venezuela).

dominicii Ortiz

Culicoides dominicii Ortiz, 1951a, 7 (♂, Ocumare del Tuy, Miranda, Venezuela). Mirsa and Ortiz, 1952, 475 (♀, Venezuela).
Culicoides (*Oecacta*) *dominicii* Khalaf, 1954, 38.

dovei Hall

See *Culicoides furens* (Poey).

efferus Fox

Culicoides efferus Fox, 1952a, 365 (♀, Rio Charape, Peru).

elutus Macfie

Culicoides elutus Macfie, 1948, 75 (♀, El Carrizal, Chiapas, Mexico). Vargas, 1949b, 197. Wirth, 1952a, 175.

eublepharus Macfie

Culicoides eublepharus Macfie, 1948, 86 (♀, British Guiana). Vargas, 1949b, 197. Ortiz, 1952a, 129 (♂ ♀, Venezuela). Ortiz and Mirsa, 1952a, 126

filariferus Hoffman

See *Culicoides diabolicus* Hoffman.

flavivenula Lutz

Culicoides flavivenula Lutz, 1937, 418 (♀, Japuhyba, Angra dos Reis, Brazil). Floch and Abonnenc, 1942a, 3 (French Guiana). Vargas, 1945, 3. Barbosa, 1947, 15 (Brazil). Vargas, 1949b, 198.
Culicoides (*Hoffmania*) *flavivenula* Fox, 1948, 26. Ortiz, 1950, 448.
Culicoides (*Culicoides*) *flavivenula* Khalaf, 1954, 46.

flochabonnenci Ortiz and Mirsa

Culicoides flochabonnenci Ortiz and Mirsa, 1952b, 267 (♀, Los Chorros, Miranda, Venezuela).
Culicoides lichyi Ortiz and Mirsa (not Floch and Abonnenc) 1951, 601 (♀, Venezuela).

floridensis Beck

Culicoides floridensis Beck, 1951, 135 (♂ ♀, Englewood, Sarasota Co., Fla., U. S. A.). Beck, 1952, 105. Foote and Pratt, 1954, 21.

fluvialis Macfie

Culicoides fluvialis Macfie, 1940a, 25 (♀, New River, British Guiana). Vargas, 1945, 43. Barbosa, 1947, 15. Macfie, 1948, 73. Vargas, 1949b, 198. Ortiz, 1951a, 2 (♀, Venezuela). Ortiz and Mirsa, 1952b, 264 (♂, Venezuela).

fluviatilis Lutz

See *Lasiohelea fluviatilis* (Lutz).

foxi Ortiz

Culicoides foxi Ortiz, 1950, 461 (Venezuela). Ortiz, 1951a, 4 (♂ ♀, Venezuela). Ortiz, 1951b, 444 (Venezuela). Mirsa, *et al.*, 1952, 161 (Venezuela). Fox and Maldonado, 1953, 165 (Puerto Rico).

Culicoides (*Hoffmania*) *guttatus* Fox (not Coquillett), 1948, 23 (♀, in part, Venezuela).

Culicoides guttatus Fox, 1949, 31 (♂ ♀, Puerto Rico). Fox and Kohler, 1950, 342 (Puerto Rico).

Culicoides (*Culicoides*) *foxi* Khalaf, 1954, 39.

furens Poey

Oecacta furens Poey, 1851, 236 (♂ ♀, Cuba). Osten-Sacken, 1878, 23. Cockerell, 1894, 419 (Jamaica). Townsend, 1893b, 381 (Jamaica). Townsend, 1897, 17 (Mexico). Aldrich, 1905, 119. Johannsen, 1905, 102. Kieffer, 1906, 55. Pratt, 1907, 28 (Cuba; Montserrat, W. I.; Mexico). Johannsen, 1908, 267. Surcouf and González-Rincones, 1912, 307. Stephens, 1923, 368 (Cuba).

Ceratopogon maculithorax Williston, 1896, 277 (♀, St. Vincent, W. I.). Aldrich, 1905, 109.

Culicoides maculithorax Kieffer, 1906, 54. Johannsen, 1908, 267. Lutz, 1912, 21 (Brazil). Rieth, 1915, 417. Loughnan, 1921, 202 (Jamaica). Edwards, 1922, 164 (Jamaica). Gibson, 1923, 41 (British Honduras).

Culicoides furens Lutz, 1912, 16. Lutz, 1913, 53 (♀, Brazil). Root, 1922, 396 (Puerto Rico). Root, 1924, 208 (Honduras). Bequaert, 1924, 197 (Honduras). Kieffer, 1925a, 419 (♀), Hoffman, 1925, 287 (♀, Cuba; Mexico; Trinidad; Puerto Rico; Canal Zone; Bahama Group; Florida, U. S. A.). Painter, 1926, 245 (Honduras). Wolcott, 1927, 312 (Haiti). Hall, 1932, 88 (Honduras). Meyers, 1932, 1 (Bahamas). Hinman, 1932, 775 (Louisiana, U. S. A.). Buckley, 1933, 257 (St. Vincent). Buckley, 1934a, 99 (St. Vincent). Buckley, 1934b, 1. Myers, 1935, 71 (Trinidad). Van Volkenberg, 1935, 17 (Puerto Rico). Dampf, 1936a, 232 (Mexico). Atchley and Hull, 1936, 514. Wolcott, 1936, 325 (Puerto Rico). Root and Hoffman, 1937, 162 (♂ ♀, Louisiana, Texas, U. S. A.). Macfie, 1937, 10 (♂ ♀, Trinidad). Lima, 1937, 414. Tokunaga, 1937, 298. Adamson, 1939, 80 (Trinidad). Wolcott, 1941, 109 (Puerto Rico). Fox, 1942, 418 (pupa, Puerto Rico). Floch and Abonnenc, 1942b, 1 (♀, French Guiana). Johannsen, 1943, 779, Fairchild, 1943, 572 (Panama). Barretto, 1944, 89 (♂, Brazil). Beatty, 1944, 144 (St. Croix). Vargas, 1945, 44. Fox, 1946a, 255 (St. John, V. I.; Dominican Republic; Trinidad). Woke, 1947, 364 (Nicaragua). Trapido, 1947, 472 (Panama). Barbosa, 1947, 15 (♂, Trinidad; St. Croix; Nicaragua; Honduras; Venezuela; Barbados; Panama; Mexico; British Honduras; Antigua; Cuba; Bahamas; Guatemala;

Puerto Rico; Jamaica; Florida, Georgia, Maryland, Massachusetts, New Jersey, U. S. A.). Macfie, 1948, 73. Ortiz and Peña Garcia, 1948, 7 (Venezuela). Wolcott, 1948, 426 (Puerto Rico). Briceño-Iragorry, 1949, 318 (Venezuela). Ortiz, 1949, 328 (Venezuela). Dove, 1949, 869 (Florida, U. S. A.). Floch and Abonnenc, 1949a, 71. Floch and Abonnenc, 1949b, 1343 (French Guiana). Vargas, 1949b, 198. Floch and Abonnenc, 1950, 1 (Guadeloupe). Travis and Morton, 1950, 154 (Florida, U. S. A.). Fox and Kohler, 1950, 342 (Puerto Rico). Iriarte, 1950, 375. Ortiz, 1950, 462. Goulding, 1950, 102 (Florida, U. S. A.). Kohler and Fox, 1951, 113 (Puerto Rico). Ortiz, 1951a, 10 (Venezuela). Carpenter, 1951, 205 (Panama). Wirth, 1952c, 95 (larva, pupa, Florida, U. S. A.). Beck, 1952, 104 (Florida, U. S. A.). Fox, 1952b, 888. Barbosa, 1952, 13 (Ecuador). Goulding, *et al.*, 1953, 37 (Florida, U. S. A.). Fox and Maldonado, 1953, 165 (Puerto Rico). Bradley, 1954, 125. Foote and Pratt, 1954, 21 (♂♀, Florida, Georgia, Maryland, Massachusetts, Mississippi, New Jersey, South Carolina, Texas, U. S. A.). Labrecque and Goulding, 1954, 20 (Florida, U. S. A.) Woke, 1954, 71 (Panama; Nicaragua).

Culicoides dovei Hall, 1932, 88 (♂♀, Florida, Georgia, North Carolina, South Carolina, U. S. A.). Dove, *et al.*, 1942, 505 (egg, larva, pupa, ♂♀, South Carolina, U. S. A.). Hull, *et al.*, 1934, 162 (North Carolina, U. S. A.).

Culicoides (*Oecacta*) *furens* Khalaf, 1954, 37.

galindoi Wirth and Blanton

Culicoides galindoi Wirth and Blanton, 1953a, 73 (♂♀, Mojinga Swamp, Fort Sherman, C. Z.).

germanus Macfie

Culicoides germanus Macfie, 1940a, 27 (♂, New River, British Guiana) Vargas, 1945, 43. Barbosa, 1947, 17. Macfie, 1948, 74.

gibsoni Wirth

Culicoides gibsoni Wirth, 1952b, 246 (♀, Finca San Rafael, San Pedro Yepocapa, Chimaltenango, Guatemala). Gibson and Ascoli, 1952, 317 (Guatemala).

gigas Root and Hoffman

Culicoides gigas Root and Hoffman, 1937, 172 (♀, Fort a la Corne, Canada). Curtis, 1941, 18 (Canada). Leech, 1943, 23 (Canada). Johannsen, 1943, 779. Vargas, 1945, 43. Vargas, 1949b, 198. Ortiz, 1950, 463.

ginesi Ortiz

Culicoides ginesi Ortiz, 1951c, 586 (♀, San Felipe, Yaracuy, Venezuela).

gorgasi Wirth and Blanton

Culicoides gorgasi Wirth and Blanton, 1953b, 232 (♂ ♀, Las Tablas, Los Santos, Panama).

griseus Coquillett

Ceratopogon griseus Coquillett, 1901, 602.
Culicoides griseus Kieffer, 1906, 54.
REMARKS.—A species of *Dasyhelea* (Wirth, 1952a, 155).

guadeloupensis Floch and Abonnenc

Culicoides guadeloupensis Floch and Abonnenc, 1950, 2 (♀, St. Claude, Guadeloupe). Ortiz and Mirsa, 1952a, 126.

guttatus Coquillett

Ceratopogon guttatus Coquillett, 1904, 35 (♀, São Paulo, Brazil).
Culicoides guttatus Kieffer, 1906, 54. Lutz, 1912, 16 (Brazil). Lutz (in part), 1913, 58 (♀, Brazil). Neiva and Penna, 1916, 96 (Brazil). Lima, 1937, 416 (♀, Brazil). Macfie, 1939, 199 (Brazil). Vargas, 1944, 164. Barretto, 1944, 91 (♂, Brazil). Vargas, 1945, 43. Barbosa, 1947, 17 (Brazil). Wolcott, 1948, 426. Lane, 1949, 115 (♂ ♀, Brazil). Vargas, 1949b, 199. Ortiz, 1950, 440. Warmke, 1952, 474 (Brazil).
Culicoides (*Culicoides*) *guttatus* Khalaf, 1954, 39.
REMARKS.—This species has also been reported from British Honduras (Gibson, 1923, 41); Columbia (Macfie, 1932, 448); Trinidad (Macfie, 1938, 164; Adamson, 1939, 79); British Guiana (Macfie, 1940b, 185); Nicaragua (Barbosa, 1947, 17); Venezuela (Ortiz, 1951a, 9); Canal Zone (Carpenter, 1951, 205); French Guiana (Floch, 1952, 295); Guatemala (Gibson and Ascoli, 1952, 317); and Ecuador (Barbosa, 1952, 15). All of these records, however, are questionable because authors do not agree in regard to what zoological species should be ascribed to the name. In 1949 Lane synonymized the following 9 names with *guttatus*: *insignis*, *diabolicus*, *flavivenula*, *filariferus*, *bimaculatus*, *coutinhoi*, *inamollae*, *pseudodiabolicus*, and *painteri*. Other authors, however, do not agree and have their own versions concerning synonymy. In this catalogue all these names are considered good species except *filariferus* and *pseudodiabolicus* (believed to be synonoms of *diabolicus*) and *painteri*, a synonym of *inamollae*.

guttipennis Coquillett

Ceratopogon guttipennis Coquillett, 1901, 603 (♀, Medina, Ohio, U. S. A.). Aldrich, 1905, 109. Pratt, 1907, 23 (larva, pupa, ♀, Arizona, Maryland, Ohio, Texas, Virginia, U. S. A.).

Ceratopogon (*Culicoides*) *guttipennis* Lutz, 1913, 71.

Culicoides guttipennis Kieffer, 1906, 54. Malloch, 1915a, 299 (♀, Illinois, U. S. A.). Malloch, 1915b, 306. Kieffer, 1919b, 191. Hoffman, 1924, 88. Hoffman, 1925, 296 (♀, Arizona, Maryland, Texas, Virginia, U. S. A.). Leonard, 1928, 707 (New York, U. S. A.). Hinman, 1932, 774 (Louisiana, U. S. A.). Baker, 1935, 150 (larva, New York, U. S. A.). Root and Hoffman, 1937, 160 (♂ ♀, Connecticut, Louisiana, Maryland, U. S. A.). Fox 1942, 415 (pupa, Maryland, U. S. A.). Johannsen, 1943, 779. Fenton, 1944, 5 (Oklahoma, U. S. A.). Vargas, 1945, 43. Ortiz, 1950, 463. Wirth, 1951c, 318 (Virginia, U. S. A.). Khalaf, 1952b, 349 (Oklahoma, U. S. A.). Johannsen, 1952, 161. Snow and Pickard, 1953, 28 (Tennessee, U. S. A.). Foote and Pratt, 1954, 22 (♂ ♀, Florida, Georgia, Maryland, Missouri, Ohio, Oklahoma, Texas, Virginia, Vermont, U. S. A.).

Culicoides gutipennis Vargas, 1949b, 199.

Culicoides (*Oecacta*) *guttipennis* Khalaf, 1954, 38.

guyanensis Floch and Abonnenc

Culicoides guyanensis Floch and Abonnenc, 1942a, 5 (♂ ♀, Cayenne, French Guiana). Barbosa, 1947, 19 (♂, Brazil; Canal Zone; Trinidad). Macfie, 1948, 80. Vargas, 1949b, 199. Ortiz, 1950, 463. Ortiz, 1951a, 9 (Venezuela). Floch, 1952, 295 (French Guiana). Woke, 1954, 68 (Canal Zone).

Culicoides stellifer Macfie (not Coquillett), 1937, 12 (♀, Trinidad). Macfie, 1938, 165 (Trinidad). Adamson, 1939, 80 (Trinidad).

Culicoides recifensis Barbosa, 1943, 263 (♀, Brazil). Vargas, 1945, 43.

Culicoides stubalensis Fox, 1946a, 254 (♀, Trinidad).

haematopotus Malloch

Culicoides haematopotus Malloch, 1915a, 302 (♂ ♀, Urbana, Ill., U. S. A.). Malloch, 1915b, 308. Hoffman, 1925, 299 (♀, Maryland, U. S. A.). Root and Hoffman, 1937, 161 (♂ ♀, District of Columbia, Kansas, New Mexico, U. S. A.; Mexico). Thomsen, 1937, 70 (pupa, New York, U. S. A.). James, 1943, 149 (Colorado, U. S. A.). Johannsen, 1943, 779. Vargas, 1945, 44 (Mexico). Macfie, 1948, 71. Vargas, 1949b, 199. Knowlton and Fronk, 1950, 114 (Utah, U. S. A.). Ortiz, 1950, 463. Wirth, 1951c, 318 (Virginia, U. S. A.). Wirth, 1952a, 182 (♂ ♀, California, Colorado, Georgia, Louisiana, Maryland, Nevada, New Mexico, Oklahoma, Texas, U. S. A.). Khalaf, 1952b, 349 (Oklahoma, U. S. A.). Johannsen, 1952, 160. Snow and Pickard, 1953, 28 (Tennessee, U. S. A.). Foote and Pratt, 1954, 23 (♂ ♀, Florida, Georgia, Illinois, Louisiana, Michigan, New York, Ohio, Pennsylvania, Tennessee, Utah, Virginia, U. S. A.). Edmunds and Keener, Jr., 1954, 83 (Nebraska, U. S. A.).

Culicoides (*Oecacta*) *haematopotus* Khalaf, 1954, 37.

heliconiae Fox and Hoffman

Culicoides heliconiae Fox and Hoffman, 1944, 108 (♂ ♀, Maracay, Venezuela). Fox, 1946a, 256. Barbosa, 1947, 8. Macfie, 1948, 70. Vargas, 1949b, 199. Iriarte, 1950, 372. Ortiz, 1951a, 9.

Culicoides species (3) Fox, 1942, 418 (pupa, Venezuela).

Culicoides helioconiae Vargas, 1945, 43.

Culicoides (*Hoffmania*) *heliconiae* Fox, 1948, 22 (♂ ♀, Trinidad; Honduras). Ortiz, 1950, 450.

Culicoides (*Culicoides*) *heliconiae* Khalaf, 1954, 39.

hertigi Wirth and Blanton

Culicoides hertigi Wirth and Blanton, 1953b, 229 (♂ ♀, Río Hato, Coclé Prov., Panama).

hieroglyphicus Malloch

Culicoides hieroglyphicus Malloch, 1915a, 297 (♀, Ash Creek, Graham Mt., Ariz., U. S. A.). Hoffman, 1925, 280 (♀, Arizona, U. S. A.). Root and Hoffman, 1937, 158 (♂ ♀,Arizona, Kansas, Montana, U. S. A.). James, 1943, 148 (♂, Colorado, U. S. A.). Johannsen, 1943, 779. Vargas, 1945, 43. Vargas, 1949b, 199. Ortiz, 1950, 462. Knowlton and Kardos, 1951, 163 (Utah, U. S. A.). Wirth, 1952a, 176 (♂ ♀, Arizona, California, Colorado, Kansas, Nevada, New Mexico, Oklahoma, Texas, U. S. A.). Khalaf, 1952b, 349 (Oklahoma, U. S. A.). Foote and Pratt, 1954, 24 (♂ ♀, Arizona, Kansas, Montana, Nevada, New Mexico, Oklahoma, U. S. A.). Edmunds and Keener, Jr., 1954, 83 (Nebraska, U. S. A.).

Culicoides (*Selfia*) *hieroglyphicus* Khalaf, 1954, 38.

hinmani Khalaf

Culicoides hinmani Khalaf, 1952b, 353 (♂ ♀, Wichita Refuge, Okla., U. S. A.).

Culicoides (*Oecacta*) *hinmani* Khalaf, 1954, 37.

hirtipes Kieffer

Culicoides hirtipes Kieffer, 1917b, 305. Lima, 1937, 412. Vargas, 1945, 43. *Dasyhelea hirtipes* Kieffer, 1919a, 64. Macfie, 1948, 69. Vargas, 1949b, 199.

REMARKS.—Lane and Ortiz, 1950, 460, consider this species to be a synonym of *caridei* Brèthes, which they believe to be a *Dasyhelea*.

hirtulus Coquillett

See *Culicoides obsoletus* Meigen.

hoffmani Fox

Culicoides hoffmani Fox, 1946a, 251 (♀, Camuto Village, Trinidad). Barbosa, 1947, 7. Macfie, 1948, 74. Wolcott, 1948, 426. Ortiz and Peña

García, 1948, 6 (Venezuela). Fox, 1949, 29 (♂♀, Puerto Rico). Ortiz 1949, 328 (Venezuela). Vargas, 1949b, 199. Floch and Abonnenc, 1949a, 72. Fox and Kohler, 1950, 342 (Puerto Rico). Iriarte, 1950, 373. Ortiz, 1950, 463. Ortiz, 1951a, 10. Fox and Maldonado, 1953, 165 (Puerto Rico).

hollensis Melander and Brues

Ceratopogon hollensis Melander and Brues, 1903, 13 (♀, Woods Hole, Mass., U. S. A.). Aldrich, 1905, 109. Kieffer, 1906, 50.
Culicoides hollensis Johannsen, 1943, 779. Vargas, 1945, 43. Vargas, 1949b, 199. Foote and Pratt, 1954, 24.

horneae Foote and Pratt

Culicoides horneae Foote and Pratt, 1954, 25 (♂, Batavia, N. Y., U. S. A.).

horticola Lutz

Culicoides horticola Lutz, 1913, 61 (♀, Tatuhy, São Paulo, Brazil). Rieth 1915, 417. Lima, 1937, 420 (♀, Brazil). Floch and Abonnenc, 1942a, 4 (♀, French Guiana). Vargas, 1945, 43. Macfie, 1948, 74. Vargas, 1949b, 199. Ortiz, 1951a, 10 (Venezuela).
Culicoides horticula Barbosa, 1947, 7.

hylas Macfie

Culicoides hylas Macfie, 1940a, 26 (♀, New River, British Guiana). Vargas, 1945, 43. Barbosa, 1947, 9. Macfie, 1948, 70.

inamollae Fox and Hoffman

Culicoides inamollae Fox and Hoffman, 1944, 110 (♂♀, Mayagüez, P. R.). Vargas, 1945, 43. Fox, 1946a, 257. Barbosa, 1947, 9. Vargas, 1949b, 200. Fox and Kohler, 1950, 342 (Puerto Rico). Kohler and Fox, 1951, 113 (Puerto Rico). Fox, 1952b, 888 (Puerto Rico). Fox and Maldonado, 1953, 165 (Puerto Rico). Foote and Pratt, 1954, 25 (♂♀, Florida, U. S. A.; Puerto Rico).
Culicoides oliveri Fox and Hoffman (in part), 1944, 108 (♂, Haiti).
Culicoides painteri Fox, 1946a, 258 (♀, Honduras).
Culicoides (*Hoffmania*) *inamollae* Fox, 1948, 25 (♂♀, Florida, U. S. A.). Wolcott, 1948, 426.
Culicoides (*Hoffmania*) *painteri* Fox, 1948, 26 (♂♀, Honduras).
Culicoides insignis Ortiz and Peña Garcia (not Lutz), 1948, 6 (Venezuela). Ortiz, 1949, 328 (Venezuela). Floch and Abonnenc, 1949a, 72 (Venezuela). Ortiz, 1950, 441 (♂♀, Venezuela). Ortiz, 1951a, 9 (Venezuela).
Culicoides guttatus Beck (not Coquillett), 1952, 102 (Florida, U. S. A.).
Culicoides (*Culicoides*) *inamollae* Khalaf, 1954, 46.

indianus Macfie

See *Culicoides verecundus* Macfie.

insignis Lutz

Culicoides insignis Lutz, 1913, 51 (♂ ♀, pupa, Rio de Janeiro, Brazil). Lutz 1912, 21. Rieth, 1915, 417. Lima, 1937, 415 (♀, Brazil). Vargas, 1945, 43. Barbosa, 1947, 20 (♂, Brazil). Vargas, 1949b, 200. Iriarte, 1950, 389. Ortiz, 1950, 462. Barbosa, 1952, 17 (Brazil).

Culicoides guttatus Lutz (not Coquillett, in part), 1913, 58 (♀, Brazil).

Culicoides (*Hoffmania*) *insignis* Fox, 1948, 25.

Culicoides (*Culicoides*) *insignis* Khalaf, 1954, 39.

REMARKS.—Floch and Abonnenc, 1942b, 1, have reported this species from French Guiana and Macfie, 1948, 75, doubtfully ascribed the name to specimens from Mexico. There has been so much disagreement in regard to the identification of this species that its distribution outside of Brazil is uncertain.

iriartei Fox

Culicoides iriartei Fox, 1952a, 368 (♀, La Salina, Edo. Zulia, Venezuela).

Culicoides vargasi Wirth and Blanton, 1953a, 74 (♂ ♀, Las Tablas, Los Santos, Prov., Panama; Venezuela).

REMARKS.—The above synonymy is given on the authority of Wirth (personal communication).

jamaicensis Edwards

Culicoides loughnani var. *jamaicensis* Edwards, 1922, 165 (♀, Kingston, Jamaica). Hoffman, 1925, 283 (Panama). Lima, 1937, 413. Fairchild, 1943, 572 (Panama). Johannsen, 1943, 779. Vargas, 1945, 43. Macfie, 1948, 80 (Mexico). Ortiz, 1950, 463.

Culicoides loughnani Fox (not Edwards), 1946a, 254 (Jamaica). Ortiz and Mirsa, 1952b, 271 (♂ ♀, Venezuela).

Culicoides longhnani var. *jamaicensis* Barbosa, 1947, 21 (♂, Panama; Jamaica; St. Croix).

Culicoides loughmani var. *jamaicensis* Vargas, 1949b, 201.

Culicoides loughnani jamaicensis Fox, 1949, 32 (♂ ♀, Puerto Rico). Fox and Kohler, 1950, 342 (Puerto Rico). Kohler and Fox, 1951, 113 (Puerto Rico). Ortiz, 1951a, 9 (Venezuela). Ortiz, 1951b, 442 (Venezuela). Fox, 1952b, 888 (Puerto Rico). Fox and Maldonado, 1953, 165 (Puerto Rico).

jamesi Fox

Culicoides jamesi Fox, 1946b, 244 (♂ ♀, Hamilton, Mont., U. S. A.). Vargas, 1949b, 200. Ortiz, 1950, 463. Wirth, 1952a, 178 (♂ ♀, California,

Colorado, Montana, Washington, U. S. A.; Canada). Foote and Pratt, 1954, 26 (♂, Colorado, Montana, U. S. A.).
Culicoides (*Selfia*) *jamesi* Khalaf, 1954, 38.

kintzi Wirth and Blanton

Culicoides kintzi Wirth and Blanton, 1953a, 72 (♂♀, Mojinga Swamp, Fort Sherman, C. Z.).

lanei Ortiz

Culicoides lanei Ortiz, 1950, 431 (♂, Cerro Sefa (?), Panama). Ortiz, 1951c, 557 (♂, Panama).
Culicoides (*Oecacta*) *lanei* Khalaf, 1954, 37.

leoni Barbosa

Culicoides leoni Barbosa, 1952, 17 (♀, Sto. Domingo, Ecuador).

leopoldoi Ortiz

Culicoides leopoldoi Ortiz, 1951c, 579 (♀, Ocumare del Tuy, Miranda, Venezuela). Ortiz and Mirsa, 1951, 596 (♂, Venezuela). Ortiz and Mirsa, 1952a, 127 (♀, Venezuela; Panama).

levis Coquillett

Ceratopogon levis Coquillett, 1901, 604.
Culicoides levis Kieffer, 1906, 54.
REMARKS.—A species of *Atrichopogon* (Wirth, 1952a, 121).

lichyi Floch and Abonnenc

Culicoides lichyi Floch and Abonnenc, 1949a, 69 (♀, Río Borburata, Venezuela). Ortiz, 1951a, 10. Ortiz and Mirsa, 1952a, 125.

limai Barretto

Culicoides limai Barretto, 1944, 99 (♂, Mogí das Cruzes, São Paulo, Brazil). Barbosa, 1947, 8. Vargas, 1949b, 201. Ortiz, 1950, 463. Ortiz and Mirsa, 1951, 597. (♂, Venezuela). Ortiz and Mirsa, 1952b, 265 (♀, Venezuela)
Culicoides (*Oecacta*) *limai* Khalaf, 1954, 37.

lituratus Williston

Ceratopogon lituratus Williston, 1896, 281.
Culicoides lituratus Kieffer, 1906, 54.
REMARKS.—A species of *Atrichopogon* (Macfie, 1948, 68).

lopesi Barretto

Culicoides lopesi Barretto, 1944, 102 (♂, Mogí das Cruzes, São Paulo, Brazil). Barbosa, 1947, 6. Vargas, 1949b, 201. Ortiz, 1950, 463.
Culicoides (Oecacta) lopesi Khalaf, 1954, 37.

lotus Williston

Ceratopogon lotus Williston, 1896, 282.
Culicoides lotus Kieffer, 1906, 54.
REMARKS.—A species of *Forcipomyia* (Macfie, 1948, 68).

loughnani Edwards

Culicoides loughnani Edwards, 1922, 165 (♀, Kingston, Jamaica). Hoffman, 1925, 282. Lima, 1937, 413. Johannsen, 1943, 779. Vargas, 1945, 43. Macfie, 1948, 72. Beck, 1952, 104 (Florida, U. S. A.). Foote and Pratt, 1954, 26 (♂ ♀, Florida, U. S. A.).
Culicoides laughnani Beatty, 1944, 144 (St. Croix).
Culicoides longhnani Barbosa, 1947, 21.
Culicoides loughmani Vargas, 1949b, 201.

loughnani var. jamaicensis Edwards

See *Culicoides jamaicensis* Edwards.

luteovenus Root and Hoffman

Culicoides luteovenus Root and Hoffman, 1937, 156 (♂ ♀, San Jacinto, D. F., Mexico). Johannsen, 1943, 779. Vargas, 1945, 44 (Mexico). Barbosa, 1947, 21 (Canal Zone). Macfie, 1948, 76 (Mexico). Vargas, 1949b, 201. Knowlton and Fronk, 1950, 114 (Utah). Ortiz, 1950, 463. Wirth, 1952a, 175 (♂ ♀, California, Utah, Washington, U. S. A.; Mexico).
Culicoides (Culicoides) luteovenus Khalaf, 1954, 39.

lutzi Lima

Culicoides lutzi Lima, 1937, 419 (♀, Abaeté, Pará, Brazil). Floch and Abonnenc, 1942a, 2 (♀, French Guiana). Floch and Abonnenc, 1942b, 2 (♂, French Guiana). Vargas, 1945, 43. Barbosa, 1947, 8. Vargas, 1949b, 201. Ortiz, 1951a, 9 (Venezuela). Floch, 1952, 295 (French Guiana).
Culicoides (Hoffmania) lutzi Fox, 1948, 22. Ortiz, 1950, 448.
Culicoides (Culicoides) lutzi Khalaf, 1954, 46.

macrostigma Wirth and Blanton

Culicoides macrostigma Wirth and Blanton, 1953b, 230 (♂ ♀, Mojinga Swamp, Fort Sherman, C. Z.).

maculithorax Williston

See *Culicoides furens* (Poey).

magnipalpis Wirth and Blanton

Culicoides magnipalpis Wirth and Blanton, 1953a, 76 (♂♀, Cerro Campaña, Panama).

maruim Lutz

Culicoides maruim Lutz, 1913, 48 (egg, pupa, ♀, Rio de Janeiro, Brazil; Trinidad). Rieth, 1915, 417. Lima, 1937, 412. Barbosa, 1947, 29 (♂♀ Brazil). Macfie, 1948, 71. Briceño-Iragorry, 1949, 318 (Venezuela). Floch and Abonnenc, 1949a, 79. Iriarte, 1950, 363. Ortiz, 1951a, 8. Barbosa, 1952, 18 (pupa, Brazil).

Culicoides marium Vargas, 1945, 43. Vargas, 1949b, 201.

Culicoides (*Hoffmania*) *maruim* Fox, 1948, 22 (♂♀, Brazil).

Culicoides trinidadensis Hoffman, 1925, 286 (♀, Trinidad). Myers, 1935, 71 (Trinidad). Macfie, 1937, 9. Lima, 1937, 416. Johannsen, 1943, 780. Vargas, 1945, 43. Fox, 1946a, 256 (Trinidad). Barbosa, 1947, 27. Macfie, 1948, 75.

Culicoides (*Hoffmania*) *trinidadensis* Fox, 1948, 23 (♀, Trinidad). Ortiz, 1950, 450.

Culicoides (*Culicoides*) *marium* Khalaf, 1954, 46.

melleus Coquillett

Ceratopogon melleus Coquillett, 1901, 604 (♀, Lake Worth, Fla., U. S. A.). Aldrich, 1905, 109.

Culicoides melleus Kieffer, 1906, 54. Hoffman, 1925, 278 (♀, Maryland, U. S. A.). Hoffman, 1926a, 159 (Mississippi, U. S. A.). Dove, *et al.*, 1932 508 (South Carolina, U. S. A.). Atchley and Hull, 1936, 514. Root and Hoffman, 1937, 152. Johannsen, 1943, 779. Vargas, 1945, 43. Goulding, *et al.*, 1951, 9 (Florida, U. S. A.). Johannsen, 1952, 159. Beck, 1952, 104 (Florida, U. S. A.). Wirth, 1952c, 94 (larva, pupa, Florida, U. S. A.). Bradley, 1954, 126. Foote and Pratt, 1954, 27 (♂♀, Florida, Georgia, Maryland, Massachusetts, Mississippi, New York, U. S. A.).

Culicoides meleus Vargas, 1949b, 201.

mississippiensis Hoffman

See *Culicoides canithorax* Hoffman.

minutissimus Zetterstedt

See *Culicoides pumilus* Winnertz.

miyamotoi Wirth and Blanton

See *Culicoides aureus* Ortiz.

mohave Wirth

Culicoides mohave Wirth, 1952a, 187 (♂♀, Vidal, San Bernardino Co., Calif.; Arizona, U. S. A.).
Culicoides (*Oecacta*) *mohave* Khalaf, 1954, 37.

mojingaensis Wirth and Blanton

Culicoides mojingaensis Wirth and Blanton, 1953b, 232 (♂♀, Mojinga Swamp, Fort Sherman, C. Z.).

monoensis Wirth

Culicoides monoensis Wirth, 1952a, 193 (♂♀, Huntoon Creek, Mono Co., Calif., U. S. A.).
Culicoides (*Oecacta*) *monoensis* Khalaf, 1954, 38.

multipunctatus Malloch

Culicoides multipunctatus Malloch, 1915a, 296 (♀, Urbana, Ill., U. S. A.)· Hoffman, 1925, 280. Root and Hoffman, 1937, 152. Johannsen, 1943, 779. Vargas, 1945, 43. Vargas, 1949b, 202, Khalaf, 1952b, 349 (♂♀, Oklahoma, U. S. A.). Johannsen, 1952, 159. Foote and Pratt, 1954, 28 (♂♀, Oklahoma, Texas, U. S. A.).
Culicoides (*Selfia*) *multipunctatus* Khalaf, 1954, 38.

mutabilis Coquillett

Ceratopogon mutabilis Coquillett, 1901, 602.
Culicoides mutabilis Kieffer, 1906, 54.
REMARKS.—A species of *Dasyhelea* (Wirth, 1952a, 157).

nanus Root and Hoffman

Culicoides nanus, Root and Hoffman, 1937, 165 (♂♀, Gwynn's Falls Park, Baltimore, Md., U. S. A.). Fox, 1942, 417 (pupa, Maryland, U. S. A.). Johannsen, 1943, 779. Vargas, 1945, 43. Vargas, 1949b, 202. Ortiz, 1950, 463. Khalaf, 1952b, 349 (Oklahoma, U. S. A.). Beck, 1952, 104 (Florida, U. S. A.). Johannsen, 1952, 160. Foote and Pratt, 1954, 28 (♂♀, Georgia, South Carolina, U. S. A.).
Culicoides (*Oecacta*) *nanus* Khalaf, 1954, 37.

niger Root and Hoffman

Culicoides niger Root and Hoffman, 1937, 168 (♂♀, Bay Shore near Baltimore, Md., U. S. A.). Fox, 1942, 417 (pupa, Maryland, U. S. A.).

Johannsen, 1943, 779. Vargas, 1945, 43. Vargas, 1949b, 202. Ortiz, 1950, 463. Beck, 1952, 104 (Florida, U. S. A.). Johannsen, 1952, 160. Foote and Pratt, 1954, 28 (♂ ♀, Florida, Virginia, U. S. A.).

Culicoides (*Oecacta*) *niger* Khalaf, 1954, 37.

nocivum Harris

Simulium nocivum Harris, 1862, 602 (Massachusetts, U. S. A.).

Ceratopogon nocivum Osten Sacken, 1878, 14. Aldrich, 1905, 109.

Culicoides nocivum Johannsen, 1943, 779. Vargas, 1945, 43. Vargas, 1949b, 202. Foote and Pratt, 1954, 29.

obnoxius Fox

Culicoides obnoxius Fox, 1952a, 365 (♀, Mount Marahuaca, Venezuela).

obsoletus Meigen

Ceratopogon obsoletus Meigen, 1818, 76 (Europe).

Culicoides obsoletus Edwards, 1926, 405 (♀, England; North America). Jobling, 1928, 211. Twinn, 1931, 248 (Canada). Goetghebuer and Lenz, 1934, 45 (Europe). Mayer, 1934, 205 (larva, pupa). Root and Hoffman, 1937, 155 (♂ ♀, Kansas, Montana, New York, Tennessee, U. S. A.; Canada). Hearle, 1938, 29 (Canada). Edwards, 1939, 143 (♂ ♀, England). Curtis, 1941, 18 (Canada). James, 1943, 148 (Colorado, U. S. A.). Johannsen, 1943, 779. Vargas, 1945, 43. Hill, 1947, 97 (egg, larva, pupa, England). Hill and Roberts, 1947, 160. Jenkins, 1948, 153 (Alaska). Vargas, 1949b, 202. Ortiz, 1950, 463. Wirth, 1951a, 77 (♀, Alaska). Wirth, 1951c, 318 (Virginia, U. S. A.). Williams, 1951a, 181 (Alaska). Wirth, 1952a, 169 (♂ ♀, California, Colorado, Indiana, Maryland, Massachusetts, Missouri, Montana, New Hampshire, New York, Ohio, Oklahoma, Pennsylvania, Tennessee, Washington, U. S. A.; Alaska; Canada). Beck, 1952, 103 (Florida, U. S. A.). Kettle and Lawson, 1952, 447 (larva, pupa, England). Johannsen, 1952, 160. Downes and Kettle, 1952, 61 (♂ ♀, Scotland). Snow and Pickard, 1953, 28 (Tennessee, U. S. A.). Gerry, 1953, 142 (Massachusetts, U. S. A.). Bradley, 1954, 129. Foote and Pratt, 1954, 30 (♂ ♀, Georgia, Illinois, Indiana, Maryland, Massachusetts, Missouri, Montana, New Hampshire, New Jersey, New York, Ohio, Oklahoma, Pennsylvania, Tennessee, Vermont, Virginia, U. S. A.; Alaska).

Ceratopogon hirtulus Coquillett, 1900, 396 (♀, Alaska). Aldrich, 1905, 110. Kieffer, 1906, 50.

Culicoides hirtulus Root and Hoffman, 1937, 173. Johannsen, 1943, 779.

Ceratopogon sanguisuga Coquillett, 1901, 64 (♀, Maryland, U. S. A.).

Pratt, 1907, 26 (Maryland, U. S. A.; Canada). Leonard, 1928, 707 (New York, U. S. A.).

Culicoides sanguisugus Malloch, 1951a, 301 (♂ ♀, Illinois, U. S. A.). Malloch, 1915b, 307. Cole and Lovett, 1921, 213 (Oregon, U. S. A.). Hoffman, 1925, 281 (♀, District of Columbia, Maine, Maryland, New Hampshire, New York, Pennsylvania, South Carolina, U. S. A.; Canada). Gerry, 1950, 191 (Massachusetts, U. S. A.).

Culicoides biguttatus Jenkins (not Coquillett), 1948, 154.

Culicoides (Culicoides) obsoletus Khalaf, 1954, 39.

REMARKS.—In addition to being widely distributed in Europe and North America, this species occurs in Japan (Tokunaga, 1940, 143).

ocumarensis Ortiz

Culicoides ocumarensis Ortiz, 1950, 455 (♂ ♀, Ocumare del Tuy, Miranda, Venezuela). Ortiz, 1951a, 9. Ortiz, 1951b, 442.

Culicoides (Culicoides) ocumarensis Khalaf, 1954, 46.

oliveri Fox and Hoffman

Culicoides oliveri Fox and Hoffman (in part), 1944, 108 (♀, Mariani, Haiti). Vargas, 1945, 43. Fox, 1946a, 250 (♀, Haiti). Barbosa, 1947, 9. Macfie, 1948, 70. Vargas, 1949b, 203. Ortiz, 1950, 449.

Culicoides (Hoffmania) oliveri Fox, 1948, 23.

Culicoides (Culicoides) oliveri Khalaf, 1954, 46.

ortizi Fox

See *Culicoides venezuelensis* Ortiz and Mirsa.

ousairani Khalaf

Culicoides ousairani Khalaf, 1952b, 354 (♂ ♀, Wichita Refuge, Okla., U. S. A.).

Culicoides (Oecacta) ousairani Khalaf, 1954, 37.

pachymerus Lutz

Culicoides pachymerus Lutz, 1914, 83 (♀, Amazonas, Brazil). Bequaert, 1926, 203 (Brazil). Lima, 1937, 421. Barbosa, 1947, 22. Macfie, 1948, 69. Vargas, 1949b, 203.

Culicoides pachimerus Vargas, 1945, 43.

painteri Fox

See *Culicoides inamollae* Fox.

palmerae James

Culicoides palmerae James, 1943, 151 (♂ ♀, Ft. Collins, Colo., U. S. A.). Vargas, 1945, 43. Vargas, 1949b, 203. Knowlton and Fronk, 1950, 114. (Utah, U. S. A.). Wirth, 1952a, 191 (♂ ♀, California, Utah, U. S. A.). Foote and Pratt, 1954, 30 (♂ ♀, Colorado, Montana, Nevada, New Mexico, Wyoming, U. S. A.). Edmunds and Keener, Jr., 1954, 83 (Nebraska, U. S. A.).

Culicoides (Oecacta) palmerae Khalaf, 1954, 38.

palpalis Macfie

See *Culicoides verecundus* Macfie.

pampoikilus Macfie

Culicoides pampoikilus Macfie, 1948, 79 (♀, El Vergel, Chiapas, Mexico). Vargas, 1949b, 203.

panamensis Barbosa

Culicoides panamensis Barbosa, 1947, 22 (♂ ♀, Barro Colorado, C. Z.). Vargas, 1949b, 203. Ortiz, 1950, 463.

panamericanus Fox

See *Culicoides acotylus* Lutz.

paraensis Goeldi

Haematomyidium paraense Goeldi, 1905, 137 (♀, Pará, Brazil). Kieffer 1906, 66.

Culicoides paraensis Lutz, 1913, 55 (♀, Brazil). Rieth, 1915, 23. Neiva and Penna, 1916, 96 (Brazil). Wille, 1925, 415 (Brazil). Lutz and Núñez Tovar, 1928, 13 (♀, Venezuela). Macfie, 1932, 486 (♀, Trinidad). Dunn, 1934, 178 (Panama). Buckley, 1934a, 99 (St. Vincent). Lima, 1937, 414. Macfie, 1938, 164 (Grenada). Macfie, 1939, 200 (Brazil). Martorell, 1939, 210 (Venezuela). Ortiz, 1942, 258 (Venezuela). Floch and Abonnenc, 1942a, 4 (♀, French Guiana). Johannsen, 1943, 779. Fairchild, 1943, 572 (Panama). Iriarte, 1943, 192 (Venezuela). Barretto, 1944, 92 (♂, Brazil). Ortiz, 1944, 248 (Venezuela). Vargas, 1945, 43. Fox, 1946a, 250. Briceño-Iragorry, 1946, 398 (Venezuela). Anduze, *et al.*, 1947, 11 (Venezuela). Barbosa, 1947, 23 (Brazil; Panama; Peru; Venezuela). Macfie, 1948, 72. Ortiz and Peña Garcia, 1948, 7 (Venezuela). Briceño-Iragorry, 1949, 318 (Venezuela). Ortiz, 1949, 326. Vargas, 1949b, 203. Floch and Abonnenc, 1949a, 71. Floch and Abonnenc, 1949b, 1343 (French Guiana). Romaña and Wygodzinsky, 1950, 31 (Argentina). Iriarte, 1950, 363. Ortiz, 1950, 464. Ortiz, 1951a, 10. Ortiz, 1951c, 574

(♂♀, Venezuela). Barbosa, 1952, 19 (Argentina; Bolivia; Brazil). Gibson and Ascoli, 1952, 317 (Guatemala). Floch, 1952, 295 (French Guiana). Mirsa, *et al.*, 1952, 161 (Venezuela). Tucker, 1952, 349 (Barbados). Macfie, 1953, 102 (Costa Rica). Woke, 1954, 71 (Panama).

Culicoides undecimpunctatus Kieffer, 1917b, 307 (♀, Argentina). Lima, 1937, 414. Macfie, 1948, 72.

Culicoides (*Oecacta*) *paraensis* Khalaf, 1954, 37.

paucienfuscatus Barbosa

Culicoides paucienfuscatus Barbosa, 1947, 23 (♀, Manaus, Amazonas, Brazil; Panama). Vargas, 1949b, 203.

phlebotomus Williston

Ceratopogon phlebotomus Williston, 1896, 281 (♀, St. Vincent Island, B. W. I.). Aldrich, 1905, 109.

Culicoides phlebotomus Kieffer, 1906, 55. Lutz, 1912, 16. Lutz, 1913, 70. Wolcott, 1923, 210 (Puerto Rico). Wolcott, 1924, 169. Root, 1924, 208 (Honduras). Hoffman, 1925, 285 (♀, Puerto Rico). Painter, 1926, 258 (Honduras). Ciferri, 1929, 520 (Dominican Republic). Wolcott, 1936, 325 (Puerto Rico). Root and Hoffman, 1937, 151. Lima, 1937, 414. Fox, 1942, 419 (pupa, Virgin Islands). Johannsen, 1943, 779. Vargas, 1945, 43. Fox, 1946a, 252 (St. Croix). Barbosa, 1947, 24 (Trinidad). Macfie, 1948, 72. Wolcott, 1948, 426. Vargas, 1949b, 204. Fox and Kohler, 1950, 342 (Puerto Rico). Iriarte, 1952, 526 (Venezuela). Wirth and Blanton, 1953c, 114 (♂♀, Puerto Rico, Mexico; Honduras; Nicaragua; Panama; Venezuela; Brazil). Ortiz and Mirsa, 1952b, 275 (♂♀, Venezuela). Fox and Maldonado, 1953, 165 (Puerto Rico). Woke, 1954, 71 (Nicaragua).

Culicoides amazonius Macfie, 1935a, 52 (♂♀, Brazil). Macfie, 1937, 7 (Trinidad; Tobago). Adamson, 1939, 79 (Trinidad). Floch and Abonnenc, 1942a, 3 (♀, French Guiana). Floch, 1952, 295 (French Guiana).

Culicoides amazonicus Vargas, 1945, 43. Barbosa, 1947, 11 (Brazil). Ortiz, 1950, 462.

Culicoides (*Oecacta*) *amazonius* Khalaf, 1954, 36.

pictipennis Phillipi

See *Culicoides venezuelensis* Ortiz and Mirsa.

pifanoi Ortiz

Culicoides pifanoi Ortiz, 1951c, 588 (♂♀, San Felipe, Yaracuy, Venezuela). Mirsa, *et al.*, 1952, 160 (Venezuela).

Culicoides tricoloratus Wirth and Blanton, 1953b, 233 (♂♀, Panama; Florida, U. S. A.).

REMARKS.—The above synonymy is given on the authority of Wirth (personal communication).

piliferus Root and Hoffman

Culicoides piliferus Root and Hoffman, 1937, 163 (♂ ♀, Baltimore, Md., U. S. A.). Johannsen, 1943, 779. Vargas, 1945, 44 (♀, Mexico). Vargas, 1949b, 204. Wirth, 1952a, 186. Beck, 1952, 104 (Florida, U. S. A.). Johannsen, 1952, 160. Snow and Pickard, 1953, 28 (Tennesee, U. S. A.). Foote and Pratt, 1954, 31 (♂ ♀, Georgia, New York, Vermont, Virginia, U. S. A.).

Culicoides (*Oecacta*) *piliferus* Khalaf, 1954, 36.

poikilonotus Macfie

Culicoides poikilonotus Macfie, 1948, 82 (♀, El Vergel, Chiapas, Mexico).

polystictus Kieffer

Culicoides polystictus Kieffer, 1921a, 181. (♀, Paraguay). Macfie, 1948, 69.

Culicoides polysticus Barbosa, 1947, 25. Vargas, 1949b, 204.

REMARKS.—The status of this species is uncertain because of its incomplete original description.

propinquus Macfie

Culicoides propinquus Macfie, 1948, 81 (♂, San Cristobal, Chiapas, Mexico). Vargas, 1949b, 204. Ortiz, 1950, 464.

Culicoides (*Oecacta*) *propinquus* Khalaf, 1954, 38.

propriipennis Macfie

Culicoides propriipennis Macfie, 1948, 84 (♀, San Cristobal, Chiapas, Mexico). Ortiz and Mirsa, 1952b, 262 (♂, Venezuela).

Culicoides propiipennis Vargas, 1949b, 204.

pseudodiabolicus Fox

See *Culicoides diabolicus* Hoffman.

pulchripennis Macfie

Culicoides pulchripennis Macfie, 1939, 200 (♀, Nova Teutonia, Brazil). Vargas, 1945, 43. Barbosa, 1947, 7. Macfie, 1948, 73. Vargas, 1949b, 204. Ortiz and Mirsa, 1952a, 125.

pulicaris Linnaeus

REMARKS.—The report of this European species in Cuba by Stephens, 1923, 368, was undoubtedly based on a misidentification.

pumilus Winnertz

Ceratopogon pumilus Winnertz, 1852, 46 (Europe).
Culicoides pumilus Edwards, 1939, 142 (♂, England). Vargas, 1945, 43 (New World).
Ceratopogon minutissimus Zetterstedt, 1855, 4860 (Scandinavia).
Culicoides minutissimus Edwards, 1926, 405 (♀, England). Johannsen, 1943, 779 (Greenland).
Culicoides (*Oecacta*) *pumilus* Khalaf, 1954, 36.
REMARKS.—This species is widely distributed in Europe (Goetghebuer and Lenz, 1934, 44; Kieffer, 1925b, 77).

pusillus Lutz

Culicoides pusillus Lutz, 1913, 52 (♀, Manguinhos, Brazil). Rieth, 1915, 417. Lima, 1937, 412. Macfie, 1938, 165 (♂ ♀, Trinidad). Adamson, 1939, 81 (Trinidad). Floch and Abonnenc, 1942b, 2 (♂ ♀, French Guiana). Vargas, 1945, 43. Barbosa, 1947, 25 (Panama; Jamaica). Macfie, 1948, 79 (Mexico). Vargas, 1949b, 205. Fox and Kohler, 1950, 342 (Puerto Rico). Ortiz, 1950, 464. Ortiz, 1951a, 8. Ortiz, 1951b, 442 (Venezuela). Ortiz and Mirsa, 1951, 603 (♂ ♀, Venezuela). Fox, 1952b, 888 (Puerto Rico). Mirsa, *et al.*, 1952, 161 (Venezuela). Fox and Maldonado, 1953, 165. (Puerto Rico).

pygmaeus Williston

Ceratopogon pygmaeus Williston, 1896, 278.
Culicoides pygmaeus Kieffer 1906, 55.
REMARKS.—A species of *Dasyhelea* (Macfie, 1948, 68).

rangeli Ortiz and Mirsa

Culicoides rangeli Ortiz and Mirsa, 1952a, 126 (♀, Los Chorros, Miranda, Venezuela).

recifei Barbosa

Culicoides recifei Barbosa, 1947, 25 (♂ ♀, Recife, Pernambuco, Brazil). Vargas, 1949b, 205. Barbosa, 1952, 20.
Culicoides insignis Barbosa (not Lutz), 1944, 259 (♂ ♀, Brazil).
Culicoides (*Culicoides*) *recifi* Khalaf, 1954, 46.

recifensis Barbosa

See *Culicoides guyanensis* Floch and Abonnenc.

reevesi Wirth

Culicoides reevesi Wirth, 1952a, 193 (♀, Bakersfield, Kern Co., Calif., U. S. A.).

reticulatus Lutz

Culicoides reticulatus Lutz, 1913, 49 (larva, ♀, Rio de Janeiro, Brazil). Lutz, 1912, 21. Rieth, 1915, 417. Lima, 1937, 413. Barbosa, 1943, 261 (♂♀, Brazil). Vargas, 1945, 43. Barbosa, 1947, 25 (Brazil). Macfie, 1948, 73. Vargas, 1949b, 205. Ortiz, 1950, 464.

riethi Kieffer

Culicoides riethi Kieffer, 1914, 237 (Europe). Root and Hoffman 1937, 159 (♀, Arizona, U. S. A.). Vargas, 1945, 43. Foote and Pratt, 1954, 12.

REMARKS.—Root and Hoffman were unable to decide whether they had an aberration of *variipennis* or whether *riethi* really occurs in the United States, hence the occurrence of the latter in the Western Hemisphere is doubtful.

rozeboomi Barbosa

Culicoides rozeboomi Barbosa, 1947, 26 (♂♀, Trinidad; Peru; Panama). Vargas, 1949b, 206. Ortiz, 1950, 452. Carpenter, 1951, 205 (Panama). Woke, 1954, 68 (Canal Zone).

Culicoides (*Culicoides*) *rozeboomi* Khalaf, 1954, 46.

salihi Khalaf

Culicoides salihi Khalaf, 1952b, 351 (♂♀, Wichita Refuge, Okla., U. S. A.)

Culicoides (*Oecacta*) *salihi* Khalaf, 1954, 37.

sanctae-marthae Kieffer

Culicoides sanctae-marthae Kieffer, 1917b, 306.

Dasyhelea sanctae-marthae Kieffer, 1919a, 64.

REMARKS.—Macfie, 1948, 69, stated that this species is not a *Culicoides*.

sanguisuga Coquillett

See *Culicoides obsoletus* Meigen.

scopus Root and Hoffman

Culicoides scopus Root and Hoffman, 1937, 170 (♂♀, San Jacinto, D. F., Mexico). Johannsen, 1943, 780. Vargas, 1945, 43. Macfie, 1948, 71. Vargas, 1949b, 206. Ortiz, 1950, 464.

Culicoides (*Oecacta*) *scopus* Khalaf, 1954, 36.

setifer Lutz

See *Culicoides caridei* (Brèthes).

simulans Root and Hoffman

See *Culicoides travisi* Vargas.

sordidellus Zetterstedt

Ceratopogon sordidellus Zetterstedt, 1838, 820 (♀, Greenland). Staeger 1844, 355. Osten Sacken, 1878, 23. Aldrich, 1905, 110.
Ceratolophus sordidellus Kieffer, 1906, 61.
Ceratopogon (Culicoides?) sordidellus Goetghebuer 1935, 310.
Johannsoniella sordidella Brumpt, 1936, 1454 (Greenland).
Culicoides sordidellus Edwards, 1938, 545 (♀, Greenland). Johannsen, 1943, 780. Vargas, 1945, 43. Vargas, 1949b, 207.

spinosus Root and Hoffman

Culicoides spinosus Root and Hoffman, 1937, 172 (♂, Baltimore, Md., U. S. A.). Johannsen, 1943, 780. Vargas, 1945, 43. Vargas, 1949b, 207. Ortiz, 1950, 464. Beck, 1952, 104 (Florida, U. S. A.). Johannsen, 1952, 160. Khalaf, 1953, 46 (♂ ♀, Oklahoma, U. S. A.). Foote and Pratt, 1954, 32 (♂ ♀, New York, Virginia, U. S. A.).
Culicoides (Oecacta) spinosus Khalaf, 1954, 38.

stellifer Coquillett

Ceratopogon stellifer Coquillett, 1901, 603 (♀, Washington, D. C., U. S. A.). Howard, 1904, 92 (Texas, U. S. A.). Aldrich, 1905, 110. Pratt, 1907, 26 (♀, Arizona, District of Columbia, Mississippi, New Mexico, Tennessee, Virginia, U. S. A.).
Ceratopogon (Culicoides) stellifer Lutz, 1913, 71.
Culicoides stellifer Kieffer, 1906, 55. Malloch, 1915a, 300 (♂ ♀, Illinois, Michigan, U.S.A.). Malloch, 1915b, 307. Hoffman, 1925, 295 (♀, District of Columbia, New Mexico, U. S. A.). Hoffman, 1926a, 159 (New York, U. S. A.). Leonard, 1928, 707 (New York, U. S. A.). Root and Hoffman, 1937, 162 (♂ ♀, Connecticut, Kansas, Maryland, Mississippi, Virginia, U. S. A.). Fox, 1942, 419 (pupa, Maryland, U. S. A.). James, 1943, 148 (Colorado, U. S. A.). Johannsen, 1943, 780. Vargas, 1945, 43. Barbosa, 1947, 26 (Colorado, Florida, Georgia, Kentucky, Maryland, Mississippi, New Mexico, Ohio, Oklahoma, South Carolina, Tennessee, Virginia, U. S. A.). Vargas, 1949b, 207. Knowlton and Fronk, 1950, 114 (Utah, U. S. A.). Ortiz, 1950, 464. Knowlton and Kardos, 1951, 163 (Utah, U. S. A.). Wirth, 1951c, 318 (Virginia, U. S. A.). Ortiz, 1951c, 576 (♀, Florida, Louisanna, U. S. A.). Wirth, 1952a, 184 (♂, California, Delaware, District of Columbia, Florida, Georgia, Maryland, New Mexico, Oklahoma, South Carolina, Tennessee, Utah, Virginia, U. S. A.). Khalaf, 1952b, 349 (Oklahoma, U. S. A.). Beck, 1952, 104 (Florida, U. S. A.). Johannsen, 1952, 160. Snow and Pickard, 1953, 28 (Tennesee, U. S. A.). Foote and Pratt, 1954, 32 (♂ ♀, Alabama, Delaware, Florida, Georgia, Illinois, Maryland, Ohio, Pennsylvania, Utah,

Virginia, U. S. A.). Edmunds and Keener, Jr., 1954, 83 (Nebraska, U. S. A.).

Culicoides (*Oecacta*) *stellifer* Khalaf, 1954, 37.

REMARKS.—Several authors have mentioned this species as occurring in Venezuela (Iriarte, 1943, 192; Ortiz, 1944, 251; Anduze, *et al.*, 1947, 11; Floch and Abonnenc, 1949a, 71; Iriarte, 1950, 363; and Ortiz, 1951a, 10) but these records appear to be based on misidentifications.

stigmalis Wirth

Culicoides stigmalis Wirth, 1952b, 245 (♀, Finca San Rafael, San Pedro Yepocapa, Chimaltenango, Guatemala). Gibson and Ascoli, 1952, 317 (Guatemala). Vargas, 1953b, 229 (♂, Mexico; Panama).

stilobezzioides Foote and Pratt

Culicoides stilobezzioides Foote and Pratt, 1954, 33 (♂, Ithaca, N. Y.).

stonei James

Culicoides stonei James, 1943, 149 (♂ ♀, Ft. Collins, Colo., U. S. A.). Vargas, 1945, 43. Vargas, 1949b, 207. Foote and Pratt, 1954, 33 (♀, Colorado, U. S. A.).

Culicoides (*Oecacta*) *stonei* Khalaf, 1954, 38.

stubalensis Fox

See *Culicoides guyanensis* Floch and Abonnenc.

stylifer Lutz

See *Lasiohelea stylifer* (Lutz).

tenuistylus Wirth

Culicoides tenuistylus Wirth, 1952a, 178 (♂ ♀, Wheeler's Springs, Ventura Co., Calif., U. S. A.).

Culicoides (*Selfia*) *tenuistylus* Khalaf, 1954, 38.

transiens Walker

Ceratopogon transiens Walker, 1848, 25 (♀, St. Martin's Falls, Albany River, Hudson's Bay). Osten Sacken, 1878, 23. Aldrich, 1905, 110. Kieffer, 1906, 52. Smith, 1900, 628. (New Jersey, U. S. A.).

Culicoides transiens Johannsen, 1943, 780. Vargas, 1949b, 207.

REMARKS.—A species of *Atrichopogon* according to Paul Freeman who studied the types in the British Museum (personal communication).

travisi Vargas

Culicoides travisi Vargas, 1949a, 233 (new name for *simulans* R.&H., preoccupied by Vimmer, 1932). Ortiz, 1950, 464. Wirth, 1951c, 318, (Virginia, U. S. A.). Beck, 1952, 104 (Florida, U. S. A.). Johannsen, 1952, 160. Snow and Pickard, 1953, 28 (Georgia, Tennessee, U. S. A.). Foote and Pratt, 1954, 33 (♂ ♀, Florida, Georgia, Maryland, New York, Ohio, Pennsylvania, Virginia, U. S. A.).

Culicoides simulans Root and Hoffman, 1937, 167 (♂ ♀, Baltimore, Md., U. S. A.). Johannsen, 1943, 779. Vargas, 1945, 43. Khalaf, 1952b, 349 (Oklahoma, U. S. A.).

Culicoides (*Oecacta*) *travisi* Khalaf, 1954, 37.

tricoloratus Wirth and Blanton

See *Culicoides pifanoi* Ortiz.

trilineatus Fox

Culicoides trilineatus Fox, 1946a, 250 (♀, Red Hook, St. Thomas, V. I.) Barbosa, 1947, 6. Macfie, 1948, 72. Wolcott, 1948, 426. Fox, 1949, 30. (♂ ♀, Puerto Rico). Fox and Kohler, 1950, 352 (Puerto Rico).

Culicoides trillineatus Vargas, 1949b, 207.

trinidadensis Hoffman

See *Culicoides maruim* Lutz.

tristriatulus Hoffman

Culicoides cockerelli var. *tristriatulus* Hoffman, 1925, 294 (♀, Eureka, Calif., U. S. A.). Root and Hoffman, 1937, 157. Johannsen, 1943, 779. Vargas, 1949b, 196. Ortiz, 1950, 462.

Culicoides tristriatulus Jenkins, 1948, 154 (Alaska). Travis, 1949, 455 (Alaska). Applewhite and Smith, 1950, 353 (Alaska). Applewhite and Cross, 1951, 21 (Alaska). Williams, 1951a, 173 (Alaska). Williams, 1951b, 430 (egg, larva, pupa, Alaska). Wirth, 1951a, 78 (♂ ♀, Alaska). Wirth, 1952a, 173 (♂ ♀, California, U. S. A.).

Culicoides sordidellus Jenkins (not Zetterstedt), 1948, 154 (Alaska).

Culicoides (*Culicoides*) *tristriatulus* Khalaf, 1954, 39.

REMARKS.—Vargas, 1945, 48, described what he believed to be the male of this species but Wirth, 1952a, 175, stated that Vargas was dealing with another species possibly *elutus* Macfie.

undecimpunctatus Kieffer

See *Culicoides paraensis* (Goeldi).

unicolor Coquillett

Ceratopogon unicolor Coquillett, 1905, 65 (♀, Eureka, Calif., U. S. A.). Kieffer, 1906, 51. Pratt, 1907, 26 (California, U. S. A.).

Culicoides unicolor Hoffman, 1925, 279 (♀, California, U. S. A.). Root and Hoffman, 1937, 152. Curtis, 1941, 18 (Canada). Johannsen, 1943, 780. Vargas, 1945, 43. Vargas, 1949b, 208. Wirth, 1951a, 85 (♂♀, Alaska). Williams, 1951a, 181 (Alaska). Wirth, 1952a, 185 (♂♀, California, Montana, Oregon, U. S. A.; Canada; Alaska).

Culicoides (*Oecacta*) *unicolor* Khalaf, 1954, 36.

uniradialis Wirth and Blanton

Culicoides uniradialis Wirth and Blanton, 1953a, 70 (♂♀, Mojinga Swamp, Fort Sherman, C. Z.)

usingeri Wirth

Culicoides usingeri Wirth, 1952a, 192 (♂♀, Hat Creek Ranger Station, Shasta, Co., Calif., U. S. A.).

Culicoides (*Oecacta*) *usingeri* Khalaf, 1954, 38.

utahensis Fox

Culicoides utahensis Fox, 1946b, 246 (♂, Logan, Utah, U. S. A.). Vargas, 1949b, 208. Knowlton and Fronk, 1950, 113 (Utah, U. S. A.). Ortiz, 1950, 464. Wirth, 1952a, 189 (♂♀, California, Idaho, Montana, Utah, U. S. A.).

Culicoides (*Oecacta*) *utahensis* Khalaf, 1954, 38.

vargasi Wirth and Blanton

See *Culicoides iriartei* Fox.

variipennis Coquillett

Ceratopogon variipennis Coquillett, 1901, 602 (♀, Richmond, Va., New Jersey, U. S. A.; Mexico). Smith, 1900, 628 (New Jersey, U. S. A.). Aldrich, 1905, 110. Pratt, 1907, 26 (New Jersey, New Mexico, Virginia, U. S. A.).

Culicoides variipennis Kieffer, 1906, 55. Hoffman, 1924, 67 (Maryland, U. S. A.). Hoffman, 1925 (,♂♀ Maryland, New York, U. S. A.). Leonard, 1928, 707 (New York, U. S. A.). Stanford, 1931, 99 (Utah, U. S. A.). Whitehead, 1934, 264 (Oklahoma, U. S. A.). Root and Hoffman, 1937, 158 (♂♀, Arizona, California, Kansas, Mississippi, New Jersey, Texas, U. S. A.; Mexico). Thomsen, 1937, 70 (pupa, New York, U. S. A.). Curtis, 1941, 18 (Canada). Fox, 1942, 414 (pupa, Maryland, U. S. A.). Johannsen, 1943, 780. James, 1943, 148 (Colorado, U. S. A.). Var-

gas, 1945, 45 (Mexico). Macfie, 1948, 71. Vargas, 1949b, 208. Knowlton and Fronk, 1950, 113 (Utah, U. S. A.). Ortiz, 1950, 464. Knowlton and Kardos, 1951, 163 (Utah, U. S. A.). Wirth, 1952a, 180 (♂♀, Arizona, California, Colorado, Georgia, Illinois, Indiana, Maryland, Mississippi, Montana, Nevada, New Jersey, New Mexico, Ohio, Oklahoma, Oregon, Texas, Washington, U. S. A.). Khalaf, 1952b, 349 (Oklahoma, U. S. A.). Johannsen, 1952, 160. Ortiz and Mirsa, 1952a, 125 (♀, Louisiana, U. S. A.). Snow and Pickard, 1953, 28 (Tennessee, U. S. A.). Foote and Pratt, 1954, 34 (♂♀, Arizona, Arkansas, Colorado, Georgia, Illinois, Indiana, Kansas, Maryland, Mississippi, Nebraska, New Jersey, Ohio, Texas, Virginia, U. S. A.) Edmunds and Keener, Jr., 1954, 83 (Nebraska, U. S. A.).

Culicoides variipennis Malloch, 1915a, 297 (pupa, ♂♀, Arizona, Illinois, U. S. A.). Adams, 1940, 125 (Missouri, U.S.A.).

Culicoides (*Monoculicoides*) *variipennis* Khalaf, 1954, 40.

REMARKS.—This species has been mentioned several times as occurring in Venezuela (Ortiz, 1942, 258; Iriarte, 1943, 192; Anduze, *et al.*, 1947, 11; Iriarte, 1950, 363; Ortiz, 1951a, 10). Ortiz and Mirsa, 1952a, 125, indicate that the record is due to a misidentification. See *Culicoides arubae* Fox and Hoffman.

venezuelensis Ortiz and Mirsa

Culicoides venezuelensis Ortiz and Mirsa, 1950, 137 (♂♀, Los Chorros, Caracas, Venezuela).

Psychophaena pictipennis Phillipi, 1865, 628 (♀, Chile; name preoccupied by Staeger, 1839). Kieffer, 1906, 65.

Psychophaena (*Culicoides*) *pictipennis* Lutz, 1913, 71.

Culicoides pictipennis Ingram and Macfie, 1931, 155. Vargas, 1945, 43. Barbosa, 1947, 24. Macfie, 1948, 80.

Culicoides ortizi Fox, 1952a, 366 (♀, Venezuela).

venustus Hoffman

Culicoides venustus Hoffman, 1925, 290 (♀, Baltimore, Md., U. S. A.). Hoffman, 1926a, 159 (New York, U. S. A.). Leonard, 1928, 707 (New York, U. S. A.). Root and Hoffman, 1937, 155 (♂♀, Connecticut, U. S. A.). Thomsen, 1937, 70 (larva, pupa, New York, U. S. A.). Johannsen, 1943, 780. Vargas, 1945, 43. Vargas, 1949b, 208. Beck, 1952, 102 (Florida, U. S. A.). Snow and Pickard, 1953, 28 (Tennessee, U. S. A.). Foote and Pratt, 1954, 35 (♂♀, Alabama, Delaware, Florida, Georgia, Maryland, Mississippi, North Carolina, Ohio, Pennsylvania, Vermont, Virginia, U. S. A.).

Culicoides (*Hoffmania*) *venustus* Fox, 1948, 28 (♂ ♀). Ortiz, 1950, 446. Johannsen, 1952, 160.
Culicoides (*Culicoides*) *venustus* Khalaf, 1954, 39.

verecundus Macfie

Culicoides verecundus Macfie, 1948, 76 (♂ ♀, El Vergel, Chiapas, Mexico). Vargas, 1949b, 208. Ortiz and Mirsa, 1952b, 259 (♂ ♀, Venezuela).
Culicoides indianus Macfie, 1940a, 25 (British Guiana; not *indianus* Macfie, 1932, 488).
Culicoides palpalis Macfie, 1948, 78 (♀, Mexico).
Culicoides (*Hoffmania*) *verecundus* Ortiz, 1950, 453.
Culicoides (*Culicoides*) *verecundus* Khalaf, 1954, 46.

villosipennis Root and Hoffman

Culicoides villosipennis Root and Hoffman, 1937, 165 (♂ ♀, Sparrow's Point near Baltimore, Md., U. S. A.). Fox, 1942, 416 (pupa, Maryland, U. S. A.). Johannsen, 1943, 780. Vargas, 1945, 43. Vargas, 1949b, 208. Wirth, 1951c, 318 (Virginia, U. S. A.). Beck, 1952, 103 (Florida, U. S. A.). Johannsen, 1952, 161. Stone and Pickard, 1953, 28 (Tennessee, U. S. A.). Foote and Pratt, 1954, 36 (♂ ♀, Georgia, Louisanna, Oklahoma, Texas, Virginia, U. S. A.).
Culicoides (*Oecacta*) *villosipennis* Khalaf, 1954, 37.

villosipennis oklahomensis Khalaf

Culicoides villosipennis oklahomensis Khalaf, 1952b, 355 (♂, Wichita Refuge, Oklahoma, U. S. A.).
Culicoides (*Oecacta*) *v. oklahomensis* Khalaf, 1954, 37.

villosipes Kieffer

Culicoides villosipes Kieffer, 1917b, 305.
Dasyhelea villosipes Kieffer, 1919, 64.
REMARKS.—Macfie, 1948, 69, stated that this species is not a *Culicoides*.

weesei Khalaf

Culicoides weesei Khalaf, 1952a, 65 (♂, Wichita Refuge, Okla., U. S. A.). Khalaf, 1952b, 351 (♀, Oklahoma, U. S. A.).
Culicoides (*Oecacta*) *weesei* Khalaf, 1954, 38.

willistoni Wirth and Blanton

Culicoides willistoni Wirth and Blanton, 1953c, 116 (♂ ♀, Río Hato, Panama).

wirthi Foote and Pratt

Culicoides wirthi Foote and Pratt, 1954, 36 (♂, Helena, Mont., U. S. A.).

wirthomyia Vargas

Culicoides wirthomyia Vargas, 1953b, 227 (♂, Iguala, Guerrero, Mexico).

wokei Barbosa

See *Culicoides diminutus* Barbosa.

wokei Fox

Culicoides wokei Fox, 1947, 91 (♀, West Bank, Balboa, C. Z.). Macfie, 1948, 73. Vargas, 1949b, 208. Woke, 1954, 68 (Canal Zone).

yukonensis Hoffman

Culicoides yukonensis Hoffman, 1925, 291 (♀, Yukon Territory, Canada). Root and Hoffman, 1937, 152. Curtis, 1941, 18 (Canada). Johannsen, 1943, 780. Vargas, 1945, 45 (Mexico). Jenkins, 1948, 153 (Alaska). Travis, 1949, 455 (Alaska). Vargas, 1949b, 208. Wirth, 1951a, 81 (♂♀, Alaska). Williams, 1951a, 181 (Alaska).
Culicoides (*Culicoides*) *yukonensis* Khalaf, 1954, 39.

LEPTOCONOPS SKUSE

This genus has recently been defined by Wirth (1952a, 110) who recognizes three Nearctic subgenera, *Leptoconops* Skuse (1889, 288), *Holoconops* Kieffer (1918, 135), and *Styloconops* Kieffer (1921b, 107), the subgeneric characters applying only to the females. Ortiz (1952b) has listed the 9 species which occur in the Western Hemisphere giving the subgenera to which they belong and a key to most of the Neotropical species. The males of only 4 of the 9 species have been described.

KEY TO THE NEARCTIC SPECIES OF LEPTOCONOPS (FEMALES)

1. Antenna with 13 segments (*Holoconops*) 2
   Antenna with 14 segments 4
2. Small species, wing 0.8–0.9 mm 3
   Larger species, wing 1.0–1.5 mm ..... *kertészi*
3. Mesonotum black contrasting with yellowish legs and abdomen ..... *bequaerti*
   Not as above, uniform reddish-brown ..... *catawbae*
4. Claws with a stout basal tooth; basitarsi with 15–20 short dark spines (*Styloconops*) ..... *freeborni*
   Claws simple; basitarsi without such spines but with slender setae (*Leptoconops*) 5

5. Fourth palpal segment half as long as third..... *floridensis*
Fourth palpal segment as long as third..... *torrens*

bequaerti (Kieffer)

Holoconops becquaerti Kieffer, 1925a, 405 (♀, Puerto Castilla, Honduras).
Leptoconops (Holoconops) hondurensis Hoffman, 1926b, 135, (♂♀, Honduras; Cuba).
Holoconops hondurensis Macfie, 1937, 2 (♀, Trinidad). Adamson, 1939, 81 (Trinidad).
Holoconops bequaerti Johannsen, 1943, 776.
Leptoconops (Holoconops) bequaerti Wirth, 1951b, 281 (Florida, Mississippi, U. S. A.; Dominican Republic; Jamaica; Venezuela). Ortiz, 1952b, 164 (Venezuela).
Leptoconops bequaerti Woke, 1954, 71 (Nicaragua). Mayer, 1934, 256 (pupa).

brasiliensis (Lutz)

Tersesthes brasiliensis Lutz, 1913, 66 (♀, Rio Tocantins, Brazil).
Protersesthes brasiliensis Kieffer, 1921b, 107.
Leptoconops braziliensis Carter, 1921, 13 (♀, Brazil).
Leptoconops brasiliensis Lane, 1945, 358 (♀, Brazil).
Leptoconops (Leptoconops) brasiliensis Ortiz, 1952b, 168.

carteri Hoffman

See *Leptoconops torrens* (Townsend).

catawbae (Boesel)

Holoconops catawbae Boesel, 1948, 69 (♀, Lakeside, Ohio, U. S. A.). Johannsen, 1952, 156.
Leptoconops (Holoconops) catawbae Wirth, 1951b, 282 (♀, Michigan, U. S. A.).

floridensis Wirth

Leptoconops (Leptoconops) floridensis Wirth, 1951b, 282 (♀, Santa Rosa Island, Escambia Co., Fla., U. S. A.). Ortiz, 1952b, 168.

freeborni Wirth

Leptoconops (Styloconops) freeborni Wirth, 1952a, 115 (♂♀, Hueneme, Ventura Co., Calif., U. S. A.).

hondurensis Hoffman

See *Leptoconops bequaerti* (Kieffer).

kertészi Kieffer

Leptoconops kertészi Kieffer, 1908, 576 (♀, Cairo, Egypt). Freeborn and Zimmerman, 1934, 261 (♂, California, U. S. A.). Knowlton and Fronk, 1950, 113 (Utah, U. S. A.). Knowlton and Kardos, 1951, 163 (Utah, U. S. A.).

Leptoconops (*Holoconops*) *kertészi* var. *americanus* Carter, 1921, 22 (♀, Utah, U. S. A.). Rees and Smith, 1950, 9 (Utah, U. S. A.).

Leptoconops kertészi var. *americanus* Knowlton, 1949, 93 (Utah, U. S. A.). Rees and Smith, 1952, 49 (Utah, U. S. A.).

Holoconops kertészi Smith and Lowe, 1948, 157 (egg, larva, pupa, ♂♀, California, U. S. A.). Boesel, 1948, 70.

Holoconops kertészi var. *americanus* Johannsen, 1943, 776.

Leptoconops (*Holoconops*) *kertészi* Wirth, 1952a, 113 (♂♀, California, Colorado, Montana, Nebraska, New Mexico, Utah, Wyoming, U. S. A.).

kertészi var. americanus Carter

See *Leptoconops kertészi* Kieffer.

petrocchiae Shannon and Del Ponte

Leptoconops petrocchiae Shannon and Del Ponte, 1927, 734 (♀, Río Tapia (La Posta), Tucumán, Argentinà).

Leptoconops (*Leptoconops*) *petrocchiae* Ortiz, 1952b, 168.

torrens (Townsend)

Tersesthes torrens Townsend, 1893a, 369 (♀, Continental Divide, N. Mex., U. S. A.). Johannsen, 1905, 96. Kieffer, 1906, 47. Pratt, 1907, 28 (Arizona, Florida, New Mexico, Utah, U. S. A.; Cuba). Kieffer, 1921b, 107. Stephens, 1923, 368 (Cuba).

Leptoconops torrens Aldrich, 1905, 107. Kieffer, 1908, 557. Kieffer, 1917a, 190 (New Mexico, U. S. A.). Carter, 1921, 15 (♂♀, New Mexico, U. S. A.). Freeborn and Zimmerman, 1934, 258 (♂, California, New Mexico, Texas, U. S. A.). Johannsen, 1943, 776 (California, Colorado, New Mexico, U. S. A.). Smith and Lowe, 1948, (larva, California, U. S. A.). Boesel, 1948, 70.

Leptoconops carteri Hoffman, 1926b, 133 (♀, California, U. S. A.).

Leptoconops (*Leptoconops*) *torrens* Wirth, 1952a, 110 (♂♀, Arizona, California, Texas, U. S. A.). Ortiz, 1952b, 168 (♀, California, U. S. A.).

venezuelensis Ortiz

Leptoconops (*Leptoconops*) *venezuelensis* Ortiz, 1952b, 165 (♀, San Carlos de Río Negro, Terr. Federal Amazonas, Venezuela).

LASIOHELEA KIEFFER 1921b

Goetghebuer and Lenz (1934, 6) considered *Lasiohelea* to be a synonym of *Forcipomyia* but recent authors (Macfie, 1940b, 15; Tokunaga, 1940, 101; Johannsen, 1943, 770) maintain the two separate. No Nearctic species have been reported but Johannsen (1943, 777) cites an undescribed species from Georgia, U. S. A. Only two of the species listed below are known to suck mammalian blood, *fluviatilis* (Lutz) and *stylifer* (Lutz).

aeronautica Macfie

Forcipomyia (*Lasiohelea*) *aeronautica* Macfie, 1935b, 265 (♀, Tumatumari, British Guiana).

bromelicola (Lutz)

Ceratopogon bromelicola Lutz, 1914, 84 (♂♀, Ilha do Governador, Rio de Janeiro, Brazil).
Apelma bromicola Saunders, 1925, 263 (larva, pupa, ♂♀, Brazil).
Lasiohelea bromelicola Lane, 1945, 360 (♂♀, Brazil).

cretea Boesel

Lasiohelea cretea Boesel, 1937, 46 (♀, Cretaceous amber, Canada).

danaisi Floch and Abonnenc

Lasiohelea danaisi Floch and Abonnenc, 1949a, 73 (♀, Rancho Grande, Aragua, Venezuela).

fluviatilis (Lutz)

Johannseniella fluviatilis Lutz, 1914, 82 (♀, Rio Negro, Massaraby, Brazil).
Culicoides fluviatilis Dunn, 1934, 178 (Panama). Fairchild, 1943, 572 (Panama).
Serromyia fluviatilis Fox, 1946a, 249.
Lasiohelea fluviatilis Lane, 1945, 363. Barbosa, 1947, 15. Vargas, 1949b, 198.

globosa Boesel

Lasiohelea globosa Boesel, 1937, 47 (♀, Cretaceous amber, Canada).

intrepida Macfie

Forcipomyia (*Lasiohelea*) *intrepida* Macfie, 1936, 228 (♀, Iquitos, Peru).

louriei Macfie

Lasiohelea louriei Macfie, 1935a, 49 (♀, Tutoia, Piauhi, Brazil).

nana Macfie

Lasiohelea nana Macfie, 1939, 171 (♀, Nova Teutonia, Brazil). Macfie, 1944, 297 (♂, Trinidad).

opilionivora Lane

Lasiohelea opilionivora Lane, 1947, 159 (♀, Juquiá, S. Paulo, Brazil).

shannoni Ingram and Macfie

Lasiohelea shannoni Ingram and Macfie, 1931, 171 (♀, L. Correntoso, Chile).

stylifer (Lutz)

Centrorhynchus stylifer Lutz, 1913, 63 (♀, Lassance, Minas, Brazil).
Lasiohelea stylifer Edwards, 1922, 166. Dunn, 1934, 178 (Panama). Macfie, 1939, 171 (Brazil). Macfie, 1940b, 181 (British Guiana). Fairchild, 1943, 572 (Panama). Macfie, 1944, 298 (Trinidad). Lane, 1945, 362 (♀, Brazil). Lane, 1947, 161 (larva, pupa, Brazil). Ortiz, 1952c, 242 (♀, Venezuela).
Culicoides stylifer Vargas, 1945, 43. Vargas, 1949b, 207.

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ARUBA.—*Culicoides arubae.*

BAHAMA.—*Culicoides furens.*

BARBADOS.—*Culicoides furens, debilipalpis, paraensis.*

BOLIVIA.—*Culicoides paraensis.*

BRAZIL.—*Culicoides acotylus, bahiensis, bambusicola, caridei, coutinhoi, debilipalpis, debilipalpis glabrior, diabolicus, flavivenula, furens, guttatus, guyanensis, horticola, insignis, limai, lopesi, lutzi, maruim, pachymerus, paraensis, paucienfuscatus, phlebotomus, pulchripennis, pusillus, recifei, reticulatus. Leptoconops brasiliensis. Lasiohelea bromelicola, fluviatilis, louriei, nana, opilionivora, stylifer.*

BRITISH GUIANA.—*Culicoides dasyophrus, debilipalpis glabrior, diabolicus, eublepharus, fluvialis, germanus, hylas, verecundus. Lasiohelea aeronautica, stylifer.*

BRITISH HONDURAS.—*Culicoides furens.*

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HONDURAS.—*Culicoides castillae, furens, heliconiae, inamollae, phlebotomus. Leptoconops bequaerti.*

JAMAICA. *Culicoides furens, jamaicensis, loughnani, pusillus. Leptoconops bequaerti.*

MEXICO.—*Culicoides acotylus, alambiculorum, albomacula, baueri, cacozelus, copiosus, crepuscularis, daedalus, dampfi, debilipalpis, diabolicus, diminutus, elutus, furens, haematopotus, jamaicensis, luteovenus, pampoikilus, phlebotomus, piliferus, poikilonotus, propinquus, propriipennis, pusillus, scopus, stigmalis, variipennis, verecundus, wirthomyia, yukonensis.*

NICARAGUA.—*Culicoides diminutus, furens, phlebotomus. Leptoconops bequaerti.*

PANAMA (INCLUDING CANAL ZONE).—*Culicoides arubae, aureus, carpenteri, dasyophrus, debilipalpis glabrior, diabolicus, diminutus, furens, galindoi, gorgasi, guyanensis, hertigi, iriartei, jamaicensis, kintzi, lanei, leopoldoi, luteovenus, macrostigma, magnipalpis, mojingaensis, panamensis, paraensis, paucienfuscatus, phlebotomus, pifanoi, pusillus, rozeboomi, stigmalis, uniradialis, willistoni, wokei. Lasiohelea fluviatilis, stylifer.*

PARAGUAY.—*Culicoides polystictus.*

PERU.—*Culicoides efferus, paraensis, rozeboomi. Lasiohelea intrepida.*

PUERTO RICO. *Culicoides borinqueni, foxi, furens, hoffmani, inamollae, jamaicensis, phlebotomus, pusillus, trilineatus.*

ST. CROIX.—*Culicoides furens, jamaicensis, loughnani, phlebotomus.*

ST. JOHN.—*Culicoides furens.*

ST. THOMAS.—*Culicoides trilineatus.*

ST. VINCENT.—*Culicoides decor, furens, paraensis, phlebotomus.*

TOBAGO.—*Culicoides phlebotomus.*

TRINIDAD.—*Culicoides debilipalpis, diabolicus, furens, guyanensis, heli-*

coniae, hoffmani, maruim, paraensis, phlebotomus, pusillus, rozeboomi, trinidadensis. Leptoconops bequaerti. Lasiohelea nana, stylifer.

UNITED STATES.—*Culicoides arboricola, baueri, biguttatus, brookmani, canithorax, chiopterus, cockerellii, c. saltonensis, copiosus, crepuscularis, denningi, floridensis, furens, guttipennis, haematopotus, hieroglyphicus, hinmani, hollensis, horneae, inamollae, jamesi, loughnani, luteovenus, melleus, mohave, monoensis, multipunctatus, nanus, niger, nocivum, obsoletus, ousairani, palmerae, pifanoi, piliferus, reevesi, salihi, spinosus, stellifer, stilobezzioides, stonei, tenuistylus, travisi, tristriatulus, unicolor, usingeri, utahensis, variipennis, venustus, villosipennis, v. oklahomensis, weesei, wirthi. Leptoconops bequaerti, catawbae, floridensis, freeborni, kertészi, torrens.* (See below).

URUGUAY.—*Culicoides caridei.*

VENEZUELA.—*Culicoides acotylus, arubae, aureus, avilaensis, baueri, beebei, benarrochei, briceñoi, cacozelus, caprilesi, cova-garciai, daedalus, dasyophrus, debilipalpis, discrepans, dominicii, eublepharus, flochabonnenci, fluvialis, foxi, furens, ginesi, guyanensis, heliconiae, hoffmani, horticola, inamollae, iriartei, jamaicensis, leopoldoi, lichyi, limai, lutzi, maruim, obnoxius, ocumarensis, paraensis, phlebotomus, pifanoi, propriipennis, pusillus, rangeli, venezuelensis, verecundus. Leptoconops bequaerti, venezuelensis. Lasiohelea danaisi, stylifer.*

GEOGRAPHIC INDEX OF THE UNITED STATES

ALABAMA.—*Culicoides crepuscularis, stellifer, venustus.*

ARIZONA.—*Culicoides crepuscularis, guttipennis, hieroglyphicus, mohave, stellifer, variipennis. Leptoconops torrens.*

ARKANSAS.—*Culicoides variipennis.*

CALIFORNIA.—*Culicoides baueri, brookmani, cockerellii, c. saltonensis, copiosus, crepuscularis, haematopotus, hieroglyphicus, jamesi, luteovenus, mohave, monoensis, obsoletus, palmerae, reevesi, stellifer, tenuistylus, tristriatulus, unicolor, usingeri, utahensis, variipennis. Leptoconops freeborni, kertészi, torrens.*

COLORADO.—*Culicoides baueri, cockerellii, crepuscularis, haematopotus, hieroglyphicus, jamesi, obsoletus, palmerae, stellifer, stonei, variipennis. Leptoconops kertészi, torrens.*

CONNECTICUT.—*Culicoides biguttatus, guttipennis, stellifer, venustus.*

DELAWARE.—*Culicoides canithorax, stellifer, venustus.*

DISTRICT OF COLUMBIA.—*Culicoides biguttatus, haematopotus, obsoletus, stellifer.*

FLORIDA.—*Culicoides arboricola, baueri, biguttatus, canithorax, crepuscularis, floridensis, furens, guttipennis, haematopotus, inamollae, loughnani, melleus, nanus, niger, obsoletus, pifanoi, piliferus, spinosus, stellifer, travisi, venustus, villosipennis. Leptoconops bequaerti, floridensis, torrens.*

GEORGIA.—*Culicoides arboricola, baueri, biguttatus, canithorax, crepuscularis, furens, guttipennis, haematopotus, melleus, nanus, obsoletus, piliferus, stellifer, travisi, variipennis, venustus, villosipennis.*

IDAHO.—*Culicoides utahensis.*

ILLINOIS.—*Culicoides arboricola, biguttatus, crepuscularis, guttipennis, haematopotus, multipunctatus, obsoletus, stellifer, variipennis.*

INDIANA.—*Culicoides obsoletus, variipennis.*

KANSAS.—*Culicoides biguttatus, crepuscularis, haematopotus, hieroglyphicus, obsoletus, stellifer, variipennis.*

KENTUCKY.—*Culicoides stellifer.*

LOUISIANA.—*Culicoides arboricola, canithorax, furens, guttipennis, haematopotus, stellifer, variipennis, villosipennis.*

MAINE.—*Culicoides canithorax, obsoletus.*

MARYLAND.—*Culicoides arboricola, baueri, biguttatus, canithorax, chiopterus, crepuscularis, furens, guttipennis, haematopotus, melleus, nanus, niger, obsoletus, piliferus, spinosus, stellifer, travisi, variipennis, venustus, villosipennis.*

MASSACHUSETTS.—*Culicoides biguttatus, canithorax, crepuscularis, furens, hollensis, melleus, nocivum, obsoletus.*

MICHIGAN.—*Culicoides crepuscularis, haematopotus, stellifer. Leptoconops catawbae.*

MINNESOTA.—*Culicoides crepuscularis.*

MISSISSIPPI.—*Culicoides arboricola, canithorax, furens, guttipennis, melleus, stellifer, variipennis, venustus. Leptoconops bequaerti.*

MISSOURI.—*Culicoides crepuscularis, guttipennis, obsoletus, variipennis.*

MONTANA.—*Culicoides biguttatus, cockerellii, crepuscularis, hieroglyphicus, jamesi, obsoletus, palmerae, unicolor, utahensis, variipennis, wirthi. Leptoconops kertészi.*

NEBRASKA.—*Culicoides crepuscularis, haematopotus, hieroglyphicus, palmerae, stellifer, variipennis. Leptoconops kertészi.*

NEVADA.—*Culicoides haematopotus, hieroglyphicus, palmerae, variipennis.*

NEW HAMPSHIRE.—*Culicoides obsoletus.*

NEW JERSEY.—*Culicoides biguttatus, canithorax, crepuscularis, furens, obsoletus, variipennis.*

NEW MEXICO.—*Culicoides crepuscularis, haematopotus, hieroglyphicus, palmerae, stellifer, variipennis. Leptoconops kertészi, torrens.*

NEW YORK.—*Culicoides biguttatus, crepuscularis, guttipennis, haematopotus, horneae, melleus, obsoletus, piliferus, spinosus, stellifer, stilobezzioides, travisi, variipennis, venustus.*

NORTH CAROLINA.—*Culicoides furens, venustus.*

OHIO.—*Culicoides biguttatus, haematopotus, guttipennis, obsoletus, stellifer, travisi, variipennis, venustus. Leptoconops catawbae.*

OKLAHOMA.—*Culicoides arboricola, crepuscularis, guttipennis, haematopotus, hieroglyphicus, hinmani, multipunctatus, nanus, obsoletus, ousairani, salihi, spinosus, stellifer, travisi, variipennis, villosipennis, v. oklahomensis, weesei.*

OREGON.—*Culicoides obsoletus, unicolor, variipennis.*

PENNSYLVANIA.—*Culicoides biguttatus, haematopotus, obsoletus, stellifer, travisi, venustus.*

SOUTH CAROLINA.—*Culicoides canithorax, furens, melleus, nanus, obsoletus, stellifer.*

SOUTH DAKOTA.—*Culicoides crepuscularis.*

TENNESSEE.—*Culicoides arboricola, baueri, biguttatus, crepuscularis, guttipennis, haematopotus, obsoletus, piliferus, stellifer, travisi, variipennis, venustus, villosipennis.*

TEXAS.—*Culicoides biguttatus, crepuscularis, furens, guttipennis, haematopotus, hieroglyphicus, multipunctatus, stellifer, variipennis, villosipennis. Leptoconops torrens.*

UTAH.—*Culicoides cockerellii, crepuscularis, haematopotus, hieroglyphicus, luteovenus, palmerae, stellifer, utahensis, variipennis. Leptoconops kertészi, torrens.*

VERMONT.—*Culicoides biguttatus, crepuscularis, guttipennis, obsoletus, piliferus, venustus.*

VIRGINIA.—*Culicoides arboricola, biguttatus, crepuscularis, guttipennis, haematopotus, niger, obsoletus, piliferus, spinosus, stellifer, travisi, variipennis, venustus, villosipennis.*

WASHINGTON.—*Culicoides crepuscularis, jamesi, luteovenus, obsoletus, variipennis.*

WYOMING.—*Culicoides crepuscularis, cockerellii, denningi, palmerae. Leptoconops kertészi.*

SUMMARY

This catalogue dealing with the bloodsucking Ceratopogonidae of the Western Hemisphere includes 198 subspecific and specific names in *Culicoides*, 12 in *Leptoconops* and 12 in *Lasiohelea*, together with most of the literature references to them which had appeared up to June 1954. A subgeneric system in *Culicoides* based particularly on the male genitalia is proposed and eight subgenera are described or redescribed: *Macfiella* (new subgenus), *Hoffmania*, Fox, *Avaritia* (new subgenus), *Culicoides* Latreille, *Selfia* Khalaf, *Monoculicoides* Khalaf, *Oecacta* Poey, and *Beltranmyia* Vargas. The species are placed in the appropriate subgenera, as far as possible, and a key is given to the males and females of the Nearctic forms. The Geographic Index lists the species reported from the geographic units of the Western Hemisphere as well as each of the states of the United States.

A brief review of the literature on biology, control, and medical importance is also included.

RESUMEN

Este catálogo trata de los ceratopogónidos hematófagos del hemisferio occidental e incluye 198 nombres específicos y subespecíficos del género *Culicoides*, 12 del género *Leptoconops* y 12 del género *Lasiohelea*. Incluye además casi todas las referencias de la literatura que han sido publicadas hasta Junio, 1954. Se ofrece un sistema de clasificación subgenérico en los *Culicoides* basado particularmente en los órganos genitales del macho. Hay descripciones de ocho subgéneros de los cuales dos son nuevos: *Macfiella* (subgénero nuevo), *Hoffmania* Fox, *Avaritia* (subgénero nuevo), *Culicoides* Latreille, *Selfia* Khalaf, *Monoculicoides* Khalaf, *Oecacta* Poey y *Beltranmyia* Vargas. Las especies están colocadas en los subgéneros apropiados hasta donde es posible y se da una clave de los machos y las hembras de las formas Neárcticas. El índice geográfico incluye las especies informadas de las unidades geográficas del hemisferio occidental así como las de cada estado de los Estados Unidos de América. Se incluye también un breve repaso sobre la biología, el control y la importancia médica de los ceretopogónidos hematófagos.

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RESEARCH NOTE

RHINOCRITUS MONILICORNIS (*PORATH*): *A BLACK AND YELLOW MILLIPEDE NEW TO PUERTO RICO*

The black millipede of which the segments are edged with greenish-yellow, which has appeared in great numbers in the metropolitan area this year, is new to Puerto Rico. Identified by H. F. Loomis of the Plant Introduction Garden at Coconut Grove, Fla. (who is also a specialist in millipedes) as *Rhinocritus monilicornis* (Porath), it has previously been recorded from Hispaniola, Dominica, Martinique, St. Martin, Barbados, Tobago, and Trinidad.

Millipedes feed on decaying vegetation, and can hardly be considered as economic pests, but are certainly a nuisance on the paths of well-kept lawns. As they appear to delight in walking on moist concrete, they congregate on the margins of swimming pools, and often fall in, and on new concrete houses often climb to the ceilings of the third and fourth stories. In an attempt to prevent them from crawling to places where they are most unwelcome, sprays of DDT, chlordane, and parathion, have not been a notable success. Even if toads do eat millipedes when on the ground, one can hardly expect toads to be able to capture them when crawling about on ceilings.

George N. Wolcott
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ERRATUM

An annoying and, as usual, inexplicable error occurred on p. 158 of THE JOURNAL OF AGRICULTURE, vol. 39, No. 3, 1955, in the article by L. A. Snyder, Alice R. Hernández, and H. E. Warmke, on The Mechanism of Apomixis in *Pennisetum Ciliare*. While the lettering was changed in the legend to figure 2 to conform to JOURNAL usage, the lettering on the illustration itself was not changed accordingly. As is obvious, K, L, M, N, O, P, Q, R, and S on the illustration itself should be A, B, C, D, E, F, G, H, and I, respectively.

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[3] Leave to pursue studies.
[4] Military leave.